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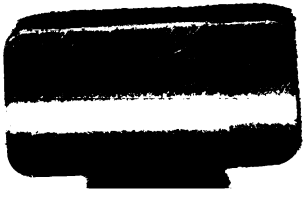
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APPLIED PRINCIPLES OF FIELD FORTIFICATION FOR LINE OFFICERS

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APPLIED PRINCIPLES

OF

FIELD FORTIFICATION

FOR

LINE OFFICERS

By J. A. WOODRUFF,
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GENERAL

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PREFACE

The following pages are written with the idea of furnishing the members of the Army School of the Line and Staff College a guide in the solution of field problems in fortification. These problems are such that any line officer might be called upon to solve in actual service. Their careful solution on varied terrain in time of peace will give an officer confidence and skill in their solution in time of war, and will avoid many costly delays and mistakes.

It is intended that this book be used with the Engineer Field Manual, Part V, on Field Fortification, so that most of the details of the subject contained in that manual are omitted.

The author desires to acknowledge assistance received from Captain Edwin T. Cole, Sixth Infantry, Senior Instructor; Captain C. O. Sherrill, Corps of Engineers; and First Lieutenant G. C. Marshall, Twenty-fourth Infantry, Instructors, Department of Engineering, Army Service Schools, for many valuable suggestions. Also to Sergeant John Howry, First Battalion of Engineers, for the preparation of the plates herein.

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Fort Leavenworth, Kansas,
February 15, 1909.

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APPLIED PRINCIPLES

—OF—

FIELD FORTIFICATION

FOR LINE OFFICERS.

CHAPTER I.

General Principles.

1. In the following discussion no attempt will be made to lay down rules or to establish typical forms of works that will be suitable to all circumstances. It should be remembered that the true essentials of a fortified position cannot be expressed on plans and maps. The disposition and the design of the defensive works should be decided on the actual ground to be defended, and only after a full consideration of the tactical circumstances. As the tactical considerations will vary greatly in different cases, it would be impossible, even if it were advisable, to lay down any system which would be applicable to all. Even the design of the individual works depends solely on the tactical considerations. Type designs are therefore useless, except as a general guide.

2. *Fortification is intimately connected with Tactics,* so much so that it would hardly be too much to say that Fortification is itself but a special branch of Tactics and not a separate division of the Military Art. Though the purely technical parts of the subject are assigned to the Engineers, yet a knowledge of the correct tactical

disposition and employment of defensive works is a necessity for every soldier.

3. The *tactical aspect of Fortification* lies in its adaptation to the natural features of the ground and to the nature of the weapons employed by either side; tactical considerations, based principally on the above, but also on the probable direction, nature, strength, and other conditions of the expected attack, will govern the general dispositions of the defensive measures, the strength of the garrison and the armament required.

4. It is the history of all modern wars that the men do not take kindly to the spade, and it is only through bitter experience that they learn the value of intrenchments. Every effort should be made, therefore, by the officers to impress this fact upon their men and, if possible, teach them the lesson at the outset, and before the enemy has the opportunity of doing so in a more forceful and costly manner.

Major Carl Reichmann, in his report on the Russo-Japanese War, states: "It may be truthfully said of the Russians, and probably of the Japanese also, that when they did not march or fight they dug."

Major J. F. Morrison states: "Great reliance was placed on field intrenchments, and their use was very general. Once in the presence of the enemy the intrenching tool seemed next in importance to the rifle and ammunition. The rule on both sides seemed to be to always cover their positions with intrenchments as soon as taken up, even when held only for a short time."

5. *Classes of Defensive Positions.*—Defensive positions may vary from the great extensive fortified position guarding some important city or strategic point liable to

be assailed by a formidable force and therefore requiring an army for its defense, to a small fortified post holding a road, a pass or a bridge head, and occupied by a small detachment.

Again, the methods of defense vary according to the weapons that may be used by the expected attacking force, and many of the measures that would be necessary against a force employing siege guns, howitzers and mortars would be unnecessary against a force with field guns alone, or without any artillery.

When troops occupy a defensive position for a considerable length of time, the field fortifications thrown up hastily at the beginning of the period will, by an energetic commander, be increased in strength until they attain a resisting power approximating that of permanent fortifications.

The position may be prepared: first, as a line barring advance along some natural line of operations; second, to surround some important nucleus which it has been determined to hold as long as possible.

A position of the first class will be held by the defending force as long as may be done without subjecting it to being surrounded and ultimately captured. The position of the Russians at Liaoyang and on the Sha River are illustrative of this class.

In the positions of the second class, the intention is to hold the position for as long a time as possible, and this usually involves the sacrifice of the defending force. Such positions are usually occupied by permanent fortifications, often supplemented by field works, as at Port Arthur. But examples in field fortification may be found in Plevna, Vicksburg, Petersburg and Sebastopol.

Any field army may therefore be called up to defend

a fortified position, and such operation may include all the refinements of regular siege operations.

Major J. E. Kuhn states: "I am of the opinion that a defensive position properly prepared and skilfully adapted to the ground will impose upon the attack methods analogous to those employed in sieges, and this without recourse to any very elaborate works of construction."

6. An *intrenched camp* or an all-around defensive position would consist at the present day of a series of fortified and strongly held positions surrounding the town or other object to be defended, and so situated in tactical relation to each other that it would be impossible for an attacker to penetrate to the interior of the defensive line without first capturing some of these positions.

The *distance of the defensive line from the nucleus* would in almost all cases be decided by the topography, but this line should be so selected as to prevent the enemy from locating any batteries within a range less than 10,000 yards from the nucleus, if aimed and observed fire is possible from the location.

Sometimes it will be sufficient to keep the enemy's position *out of sight* of the town, as unaimed and unobserved fire will seldom be effective, and it may happen that a conveniently intervening range of hills would effect this; it should, however, be remembered that observation of fire can be conducted with sufficient accuracy to hit a town or other large area from captive balloons, so the end would not be achieved if the town could be seen from balloons sent up from the besieger's positions, if the latter were within range.

It will seldom be wise in the case of a large and important town to rely on a single line of fortified positions

for its defense. Therefore, it is often desirable to keep the main defensive line at a considerable distance from the nucleus in order to leave room for a *second line* or *retired position,* in case some of the works in the front line are captured.

7. *A Defensive Line.*—The above principles apply equally to cases where the position is a straight line or an arc with secured flanks. It is imperative, however, in such cases that the flanks cannot be turned.

The defensive organization of the flanks of any position merits special attention not only because the best location for the troops that cannot be made use of in the fortifications themselves will be in outflanking echelons in rear, but also because this disposition, for the points of support on the flanks, must be adopted in preference to a break to the rear in the general line of defense. It moreover favors counter attacks upon the flank of the adversary and renders much more easy the execution of these outflanking movements whose object is to envelop the enemy's wings.

8. *Advanced positions* in front of the main line of defense often are of considerable value in delaying the besieger's progress and prolonging the defense. They form good pivots for the outpost line; they force the besiegers to deploy or to commence their siege works at a much greater distance from the place; they may even possibly necessitate a regular formal attack being undertaken against themselves, before the besieger can turn his attention to the main works. They cause, in fact, delay, which is of priceless value in a siege.

They should be selected so as to necessarily force the besiegers to stay their advance till they are taken.

They should be proof against assault over the open, and the communications to them from the main position should be secure and hidden, so that it is possible to reinforce them or withdraw their garrisons unseen. The positions should be commanded by the artillery and the infantry positions of the main line, so as to deny their use to the enemy after they have been vacated; and the works constructed on them should be of such a nature as to give no cover to the enemy.

Placed so as to easily overlook the approaches to the position, these points of support will frequently occupy the military crest or some similar position; but they must be chosen and organized so as to allow no part of them to be seen by the enemy from a distance.

The points of support of the advanced line must, moreover, satisfy as far as possible the condition of permitting an easy retreat. The latter should be prepared so as not to incommode the action of the line in rear, which constitutes the main or principal line of combat.

The advanced line will not always exist, but it will often be useful and possible to construct one, and the use of it will certainly be more frequent in the future than it has been in the past. When it does exist the resistance that it will furnish ought to be sustained as long as possible, so as to make the enemy believe that he is already in front of the main line, and to cause the attack to make great preparations to carry this line, and perhaps to make him attempt a decisive attack and thus make a useless attack, which will result in his arriving in a most critical condition in front of the main line.

It may occasionally happen that a point exists in front of the defensive line which would afford a very commanding position at short range for the enemy, and which

therefore must be occupied and held at all costs. This case is different from that of an ordinary advanced work which it is intended to vacate ultimately. Such a post must be made as strong and secure as possible, and the defenders must be given to understand that they have to hold out to the last. If covered communications cannot be provided, reliefs, supplies, etc., must be carried up at night only.

9. *Second Line.*—The object of the second line is, in the event of one of the positions in the main line having been captured, to oppose a bar to the further advance of the besiegers. Also these retired works will form pivots for the action of the general reserve, in the event of any of the besieger's troops penetrating the front line by any means.

The second line must not be commanded by the first, for in case a portion of the first line were captured, the attackers would be able to render the works of the second line untenable. It must be placed so that it is not subjected to the fire of an attack which is made upon the main line; it must be near enough to immediately receive the assailant under its fire as he starts to attack it. It will therefore have to be in a good position, if such a one can be found, about 500 or 600 yards behind the first line.

The works should, if possible, be arranged so as to bring a heavy fire upon the rear of the works in the front line in the event of their being captured; also so that the attackers cannot make a dash between them upon the town or place defended. A continuous enciente is totally unsuitable. Detached works or groups of works on tactical points are infinitely better, and it will often be found that one powerful group of works on a com-

manding but retired position will successfully dominate a large section of the defensive area. For their general disposition and design, the descriptions given in the case of the main works apply equally well, except that as a general rule they need not be so strong, and in many cases concealment will not be so necessary.

10. *Tactical Situation of the Works.*—There are three prime conditions to which every defensive position should conform:

1. It should admit of full scope for the effective use of the defender's weapons.

2. It should restrict, as far as possible, the effect of the attacker's weapons.

3. It should provide full facilities for tactical control and movement of the defender's forces.

If a hill or other commanding feature be occupied by some of the defender's troops in such a manner that they can sweep with the fire of their weapons the ground in front and on both flanks of it, then none of the attacker's troops can pass by that position within the limits of effective range of the weapons of the troops holding it. If the defenders hold two such positions situated at such a distance apart that the occupants can sweep with their fire the whole of the ground between them, then the enemy would be unable to pass between the two, or within effective range of their outer flanks.

A series of positions all around the town arranged in the above manner, so that the ground between every pair can be swept by rifle fire from the works, or artillery fire in rear, would make it impossible for the enemy to penetrate without capturing one or more of the fortified positions.

The organization of a defensive field of battle includes the utilization of natural points of support, such as woods, villages and forests, and the creation of artificial points of support. The necessity of establishing connection between the action of the various points of support over the entire extent of a defensive position does not always permit the choice of the most favorable site for each of them, but nevertheless, since there is considerable latitude in the location of the whole position and as the location of the interpolated works can often be varied within certain limits, it is well to state the advantages that are given to each point of support by the position that it occupies upon the ground. (See paragraphs 18 and 53.)

11. The *intervals* between the supporting points would not necessarily be all the same. Where the ground in the intervals is absolutely open and flat it might extend up to 2,000 to 2,500 yards; where it is less favorable it might be necessary to make it only 1,000 yards or even less. If the ground is very broken, so that there is much space concealed from view from either of the adjoining works, subsidiary works or trenches might be necessary in the intervals to cover the dead ground. On the other hand, these intervals may evidently be increased when the terrain can be covered both in front and on the flanks by a fire of artillery.

12. *All main roads* or other lines of approach by which an attacker's columns would probably advance should be covered by the fire of positions such as the above. Machine guns and artillery should also be placed so as to sweep them.

13. *Form of Supporting Points.*—It is now neces-

sary to consider what will be the form of the supporting points above mentioned. Anything in the nature of a fort or redout must always form a more or less conspicuous target, and be certain of receiving a heavy and concentrated fire from the besieger's batteries. The interior of a redout will necessarily be somewhat crowded, and heavy explosive shells dropped into crowded restricted spaces are known to have a most destructive effect. (See paragraph 42.)

It is quite possible, on account of the greatly increased defensive power of the rifles of the present day, to space the defenders of a line of parapet at much greater distances apart than was the rule in past times. A line of men with magazine rifles, four to six paces apart, behind good cover, can bring such a hail of bullets over the open ground in their front to a considerable distance from their own position as to effect terrible loss on any troops endeavoring to advance on it. Such dispersion, moreover, is advantageous in that it reduces the risk of casualties from the hostile fire, and in an immovable defensive position cannot be considered too great for effective supervision and control. (See Chapter VII, and the last part of paragraph 45.)

It seems probable, therefore, that each of the detached points that go to make up a great defensive position would consist merely of a locality or tract of ground rendered defensible by a skilful treatment of its natural features; that is to say, by the provision of simple trenches or parapets, in such a manner as to interfere as little as possible with the natural appearance of the ground.

The organization to be given to a point of support depends upon the tactical circumstances of the moment, upon the number of men that must defend it, upon the

role that it must play in the action as a whole, upon the subdivision that the commander of the defense intends to make of his forces between the garrison of the works which will form the fixed line, and the maneuvering troops, and upon the manner in which he intends to employ these last-named troops.

Major W. V. Judson, in his report on the Russo-Japanese War, states: "A fortified line, whether its plan be a closed figure embracing a city, or a straight or broken line marking the front of an army, should be marked by the absence of local and congested defensive units, which would simply form satisfactory targets for the enemy's artillery.

"Troops will and should be trained with great care in night marching and night attack. The difficulties formerly dwelt upon in connection with night attacks may be overcome by careful practice. Drill regulations should treat especially of methods and formations for conducting such operations.

"Now, the effect of this certainty of night attack is to render insecure the defense of intervals between works or between fortified pivots. The properly fortified line then becomes continuous. Individual works are ordinarily but short trenches conforming to the ground. These short trenches are not in a continuous line parallel to the front, but occupy what may be called a defensive belt, of a width varying between 200 or 300 yards and half a mile, depending upon the ground and the importance of the sector. Each of the small units is of the least possible depth (extension in the line of fire). Many should be provided with bomb-proofs. Some should be designed for fire either to front or rear. Trenches subject to enfilading fire should be of short length or broken and

well traversed. Deep covered communications, either zigzagged or traversed, should be multiplied within this belt, and connect the works with the naturally or artificially protected places for the supports. Two to four miles inside the belt, approximately parallel thereto, but concealed wherever possible by the folds of the ground or by vegetation, should be a road as well built as possible, of a width up to 60 or 80 feet for grand positions. Along the road are situated the headquarters of larger units, most of the reserves and depots of ammunitions, food supply, etc. From this great road, which would often be paralleled by rails, should branch out fan-shaped, a system of narrower roads connecting it with the supports behind the belt. These roads, especially toward the front, should be located with the greatest care to secure concealment, and, in places, might have to be sunken or traversed.

"It has been held that ease of command and control would be sacrificed if a fortified line were of the character advocated herein. This is true to a certain extent, just as command and control are sacrificed when the skirmish line is used. But in the case of the fortified line a sufficient installation of telephones will tend to remedy the evil. The Russians had four or five telephones to the mile, along the fortified belt, in addition to many behind it, and in addition to telephones for fire direction of artillery.

"With three or four thousand men to the mile of front, including all reserves, a fortified line of the belt type is invulnerable to frontal attack. It cannot be shaken by artillery fire, as the troops are protected against shrapnel, while the chances of hits by explosive shells are

exceedingly small, and the results of such hits are not serious."

14. The *conditions* that should be sought for in laying out or constructing these trenches or parapets should be, as in all other defensive works:

1. A good field of fire over all the ground over which the enemy could advance.

2. As great a measure of invisibility as it would be possible to obtain under the local conditions.

3. Good cover from rifle and ordinary artillery fire

4. Good covered and concealed means of communication with all parts of the position.

15. *Artillery Positions.*—The guns of the defense should be placed in such situation as would afford the greatest scope for their fire, combined with as great a measure of invisibility as the circumstances will admit of, and also with the power of unobserved removal and bringing up. They need not necessarily be clear of the infantry portions of the fortified positions, for the conditions are very different from those which prevailed in the confined forts of the old type. In extended positions of the type above described, it would not be difficult to find for the guns sites so placed that they would not draw on the infantry trenches the hostile artillery fire. It might often be that the best sites would be on the flanks of the infantry, but it is not necessarily so, and they might sometimes be placed so as to fire over them. (See Chapter V and paragraph 18.)

Major Kuhn states: "The Japanese showed great attention to the subject of concealment in selecting their gun positions; much of the firing was indirect. Where

no natural concealment existed, artificial concealment was provided, if possible.

"The artillery positions should, wherever possible, be located at some little distance to the rear or flank of the infantry trenches and at a safe distance from positions of supports, reserves, magazines, or anything else which one desires to protect from hostile fire. High angle fire is a little wild at the best, while direct fire gives a large danger zone to the rear from ricochet shots. Anything near the artillery positions will come in for a good bit of exposure from fire directed at the artillery, hence the importance of keeping the latter somewhat separated from other elements of the defense."

16. *Precedence of Infantry.*—If there is any question as to whether guns or infantry shall occupy any particular site, the way to settle it is to consider, not which arm is most suited for, but which form of fire it is important to have at that particular point. Generally it will be found that infantry fire is the more essential, for it must always be remembered that rifle fire forms the bedrock of all defense, and that artillery fire is but an accessory—a highly important one, but still never more than an accessory. It will generally also be found possible to find another site for guns from which the same, or nearly the same, effect can be produced, as from the point in question, while it may sometimes be dangerous to leave it without infantry defense.

17. *Concealment of the Interior of the Defended Position.*—It is of great advantage if the main defensive line can have the ground steeply sloping away from it in its immediate rear. Not only would such a conformation make it easy to provide cover for local reserves and for the defender's encampments, but it would conceal

from the enemy's view all that went on within the defender's lines. The latter condition is of infinite value and worth many sacrifices to obtain. At all events the general position taken up should, if possible, be one that admits of situations being found out of view of the enemy for the camping grounds of the defending troops; and also of the communications being concealed. If the latter cannot be achieved by natural means, it should by artificial.

18. *Command.*—It is generally considered very advantageous to place the defending works, if possible, on commanding heights. It is doubtful, however, whether beyond a certain point this is an advantage. Infantry fire with the low trajectory rifles of the present day is less effective from a height than from a low site. It is best to as near as possible graze the surface of the ground over which the attackers must advance. The same argument applies to the fire of low-trajectory, high-velocity guns; with these against troops in the open it is desirable to burst the shrapnel with as flat or grazing a trajectory as possible. For fire, either of guns or howitzers against works, an elevated position gives better searching effect, but at longe range this does not make so much difference as is generally supposed. A high site for a defensive position has also certain positive disadvantages. Hardly any hillsides are at a uniform glacis-like slope all the way up. If they are convex in section, it is impossible to avoid having a good deal of hillside and ground at the foot hidden from the defender's positions, and therefore the attackers can advance up it unseen and unharmed. If it is concave, then to be able to see and fire all down the slope, the defenders are obliged to expose themselves greatly to direct fire. Moreover, on an ele-

vated position the attacker's artillery can safely keep up a heavy fire over the heads of their advancing infantry till the very last moment.

Elevated positions derive a certain amount of advantage from the fact that it is less easy for the works to be searched out by the fire of the attacker's artillery. But well-concealed, narrow, trench-like works have in any case little to fear from this form of fire. A more positive advantage is found in the fact that elevated positions, such as those on ridges, lines of hills, etc., will nearly always give concealment from the enemy's view to the interior of the defended area. Similarly such positions permit of a range of view over the attacker's positions and enable the defenders to note his movements. Observation of artillery fire is also more accurately carried out from elevated positions.

For these last reasons, therefore, it is desirable for a defensive position to have a certain amount of command over the ground over which the enemy must advance. The actual height, however, need only be sufficient to give a good view over the ground in front, particularly to clear all obstacles to vision, such as crops, trees, undergrowth, etc., and also to obtain concealment for the interior of the defender's lines. With flat, open country it may be very little indeed. The slopes to the front should be as gentle and evenly sloping as possible.

Major Kuhn states: "From what I saw in Manchuria, I was strongly impressed by the fact that the disadvantages of a commanding position often, and generally, outweigh the advantages."

In commenting on the location of the Russian defenses on the highest ridges and hills, General Ian Hamilton states in his "Staff Officer's Scrap Book": "I am be-

coming increasingly certain, as I gain in experience, that the defense lines of the forbidding, precipitous type are in truth generally more open to attack than a simple, gently rising terrain, which furnishes those who hold it with a wide, smooth field of fire and good positions for their guns."

19. *Location of Works in the Second Line.*—The same general principles apply to the selection of the sites for works or supporting points in the second or retired line. It should be possible to bring from it a concentrated and heavy fire on any part of the outer line which has been captured, and to confront the assailants with a fresh series of works which must be carried before they can reach the object of their efforts.

20. *Good means of communication* between all parts of the general line of defense, and also from the town or headquarters to all points on the line, are of vital importance.

The facility with which artillery and the reserves will be able to move in every direction in rear of the line of battle constitutes an element of enormous weight which must be prepared for with the greatest care, and which may demand the opening of passages through woods, the construction of small bridges across streams, etc. (See paragraphs 13 and 75.)

21. *Lines of Retreat.*—Since is is necessary to foresee everything, the commander will look into the eventuality of a retreat, and will cause to be made all the necessary preparations to insure, if necessary, its good execution and to prevent the enemy from changing it into a rout. The preparation for the retreat will comprise the works of communication and the organization of points of

support for the retreat. These last will consist of positions of limited extent barring the roads and covering especially certain points that must be passed, such as bridges or various other positions at which a small force could stop the enemy quite a long time and make him lose contact with the main body of the forces, and insure the safe passage of the latter. These points of support should be echeloned in depth and the artillery will play the principal role in their defense.

CHAPTER II.

TACTICAL ORGANIZATION OF INFANTRY IN DEFENSE.

22. *Division into Sections.*—A large fortress or defensive position would be far too extensive for all the troops to be directly supervised by one man. It should therefore be sub-divided for purposes of command into several sections, each under the command of an officer with a suitable staff.

Each section should be completely independent, both tactically and as regards administration; subject, of course, to the general control of the fortress commander.

23. *Strength of the First Line, Supports and Reserves.*—Every fortified post in the front line of the section would be occupied by its own infantry garrison. In rear of the works, if possible close to them and never over 300 yards distant from them, and under good cover, will be the supports, whose strength would vary according to the necessities of the case, but would generally be from one-half to two-thirds of that of the garrison of the post. Then in rear again and at a central position as regards the whole section, would be the local or "section" reserve. Its strength would depend upon the defensive strength of the works along the front of the section. If the latter were strong and the means of communication to them were good and not long, the number of troops in the works, including their immediate supports, could be kept low, and the number in reserve increased. The advantage of this would be that it would relieve as large a number of troops as possible

from an exhausting and demoralizing life in the advance works under constant shell fire. If, however, the nature of the ground made the outer defensive position a weak one, or if the reinforcements could not reach them without long delays, then a considerable number of troops must be kept well up to the front, and the reserve would be proportionately less.

The artillery belonging to the section would usually remain either in emplacements in the front line or under cover close in rear. There might, however, be some light pieces with the section reserve troops.

The works will most frequently be combined, for the purpose of command, into groups which one battalion can defend, one portion of its defenders forming the garrison for the trenches and the other part a movable force in support, intended either to reinforce the line of fire or to be used in counter attack. Dependent upon circumstances, the battalion will ordinarily have either two companies in garrison in the trenches and two in support, or three companies in the trenches and one in support. This last subdivision is suitable for a point of support which is expected to offer only a weak resistance, or to parts of the field of battle which are approachable by the adversary with difficulty and are provided with good flank protection; the parts easily approachable and from which a vigorous resistance must be demanded, on the contrary, will have a larger movable force.

Taking into consideration the fact that the assailant will always try to bombard effectively with his artillery the works to be attacked and the approaches thereto, and that in consequence the movement from the rear to the front will be very difficult to execute without considerable losses, unless good covered approaches exist, the com-

panies of the garrison must have all of their numbers in the trenches, even though they wish at certain times to engage only a part of their forces and to keep a part for reinforcements. It seems, moreover, that the condition of never permitting the enemy to have the superiority of fire demands that, at a given moment, it should be possible to place the whole company in line immediately; and this will be most easily secured in the described manner.

24. The *position of the section reserve* would form the headquarters of the section, and should be out of sight of the enemy. It should also be on or near a main radial road of communication, and from the camp a road or roads should lead to different parts of the front line. It should be connected by telephone with each of the fortified positions in the defensive line, with headquarters and the main depots.

25. The *points of support of the second line,* like those of the first, ought always to have their fixed garrison without counting upon the movable troops; this is the only means of being certain that the works will be occupied at the proper moment. In case of taking up the offensive again, they will have to be abandoned, and the units charged with their defense will then constitute the reserve.

26. *General Reserve.*—In addition to the section reserves there should be in all cases a general reserve for the whole position. It should be encamped in a central location and should be of as mobile a nature as is practicable.

The disadvantages of the great extent of the position, which has to be taken up for defense at the present day,

is largely neutralized if a considerable portion of the defenders are kept as a mobile reserve force, as the fortified positions may in such case be few in number and far apart; they should, however, always be individually strong.

CHAPTER III.

TACTICAL EMPLOYMENT OF ARTILLERY IN DEFENSE.

27. The *disposition of the artillery* will be different from that of the infantry. It will not usually be desirable to keep any of the heavier guns or howitzers in the center of the defended area as a general reserve. As a general rule, it will be required to have all the heavy artillery in the front line from the very beginning of the siege, in order to crush the besieger's guns, and prevent his building batteries, so that only the shorter ranging pieces should be kept in rear. If, however, the defense is very weak in artillery, the guns might have to be kept under cover so as to have them available for use in the later and more critical phases, particularly in the event of an assault.

28. *Mobility.*—All the guns should be movable and there should be a large number of alternate emplacements, and good and direct communications hidden from the enemy's view. Mobility, in fact, is the chief factor.

29. *Armament.*—Generally speaking, the armament of a first-class fortress would consist mainly of howitzers and mortars from 5-inch caliber upwards. It would also have a certain number of long range heavy guns, such as the 6-inch; also a proportion of less powerful pieces, which should be of the rapid-fire class, the 4.7-inch and long 12-pounder being the most useful sizes. Long range direct-fire guns are required to keep the attackers at a distance and to act upon them if they attempt to come out into the open; howitzers and mortars are required to

search out their trenches, drop heavy shells into their gun emplacements, break down overhead cover, and search hollow ground, reverse slopes of hills, ravines, and other places where they might find cover. Howitzers and mortars are ineffective at ranges under 1,000 yards, so that for this stage of the attack, guns only can be relied on. Shrapnel fire from guns is also required against attackers in the open.

The proportion of the guns to the howitzers and mortars will depend to a certain extent on the topography. If the ground in front is broken, affording abundant cover, and precluding long range fire, then howitzers and mortars should predominate. Where the foreground is open for a long distance, or the defensive position very commanding, the proportion of guns might be greater.

30. The *location of the emplacements* for the heavy artillery will depend mainly upon the duty that each piece has to perform. Generally this duty is to operate against an enemy who is attacking the main supporting points. By this is meant that the defense of these points, rather than that of the intervals between them, is the object chiefly to be aimed at, for an attack through the intervals need not, as a rule, be feared. At the same time, means of bringing a cross fire over the intervals are not to be neglected. Certain also of the pieces, generally howitzers and mortars, will have specified duties to perform, such as to enfilade reverse slopes of hills, hollow ground or ravines, which are screened from frontal fire; and in general, the artillery positions will be so placed as to bring a heavy fire over all the ground to be traversed by the assailants.

31. The *dispersion of the guns* in an artillery position has several advantages. It renders it difficult for

the attackers to concentrate their fire; it brings a converging fire from a wide arc to bear on the object specified for attack; it permits of far greater latitude in the selection of sites for emplacements and in taking advantage of the ground to obtain concealment, and it very considerably does away with the demoralizing effect produced by a heavy shell fire in a comparatively small area. The guns should therefore be dispersed, but their fire must be capable of concentration by complete telephonic communication between the guns, observing stations and commanders.

32. *Position with Reference to the Infantry.*—If the existence of high ground in rear admits of it, the defending artillery may fire over its own infantry positions, or the artillery itself may be in two tiers, the direct firing guns being in advance, and the howitzers, firing over them from retired positions. It may be necessary for some of the guns—for instance, those entrusted with the duty of enfilading hidden ground in front of the main position—to be placed well to the flank of the infantry positions; that is to say, practically in the intervals between the supporting points. In all such cases they require to be defended by infantry, for whom intrenched positions should be provided near them. (See paragraph 15.)

It is not necessary that any of the guns may be able to defend their fronts by their own fire, as this duty can be more conveniently and effectively carried out by infantry.

33. *Location of Guns.*—A somewhat commanding position is an advantage for guns particularly for purposes of observation. If the sites are on a hill they are, for purposes of concealment, best placed a little way down

from the crest; at all events not on the sky line, provided means of access are obtainable from the rear. It may sometimes, however, be better to put them in positions somewhat drawn back from the crest of the hill. Here they will be less easy to hit, and the guns can be more easily withdrawn or brought up. It is possible that from such a position a good deal of ground at the foot of the hill could not be seen, but this could generally be dealt with by pieces from another part of the position.

34. *Location of Howitzers and Mortars.*—Howitzers and mortars, which can fire over an intervening obstacle, provided its height is not such as to intercept the projectile in its flight, and whose fire can be controlled from observing stations can, and would usually, be placed in retired situations on the reverse slope of hills, etc. Here they would be entirely unseen, and could hardly be hit. Good sites for observing stations would in such a case be of the first necessity, and these must obviously be as inconspicuous as possible.

35. *Indirect Fire for Guns.*—The heavy direct firing guns could also be fired in the same manner, if it were considered desirable to put them in retired positions; but with low trajectory weapons such positions would be less easy to find, and such an arrangement would be almost certain to result in a considerable portion of the ground at medium and short ranges being screened from the guns; moreover it is undesirable to rely entirely on observing stations which may be wrecked, so it is better that nearly all the direct firing guns should be capable of being laid direct on their objects. (See paragraph 68.)

36. *Rapid-Fire Guns.*—In addition to the heavier types of guns, it is very desirable to have for use in the later stages of the siege a number of light guns of the rapid-fire class, such as 6-pounder and 3-pounder rapid-fire and the 1-pounder automatic or pom-pom. Guns of this class are of course useless against earthworks, but they fulfil most useful functions during the later stages of a siege. For instance, in the event of an assault they will assist in bringing an overwhelming fire to bear, and at any time should the besieger offer, even for a few moments, a target in the open, their rapidity of working will permit of the opportunity being availed of.

For such guns there should be a number of alternate and well-concealed positions; the principle of their employment should be surprise, combination, and the taking advantage of every opportunity.

37. *Field Guns.*—A number of 3-inch field guns could also be most usefully employed in the defense of a fortress. They need not be assigned to any particular positions, but might be kept with the reserve troops and pushed up into any part of the front line when they are required.

38. *Machine guns* will fulfil a most useful purpose in a fortified position. They can be kept concealed when not in use, and even when in the act of firing, afford so small a target as to be hardly visible. A few such weapons in an intrenched position permit of the greater part of the garrison being kept well under cover; for in the event of an assault, they enable a heavy fire to be developed by their attendants. In the defense of a flank, in a position where a line of infantry would be visible and liable to enfilade fire, a single machine gun judiciously

posted behind a bush or rock or in a small pit could entirely escape observation. To cover particular points such as a bridge or ford, they are also most valuable. Every fortress, therefore, should be equipped with a good number of these useful weapons. Each infantry work should have some assigned to it, and there should also be a number in reserve.

CHAPTER IV.

Design of Infantry Works.

39. It is undesirable to indicate more than the general principles of the design of the works. In order to make these clear it is necessary to give some designs, with the understanding that they are not at all rigid, and should be modified to suit the ground.

40. There are *four general objects* to be aimed at in preparing a given area for defense:

1. It should have the utmost development of fire to the front, and to a somewhat less degree to the flanks.

2. The works should be so arranged that they will offer as shallow a target to the enemy as possible.

3. They should be made inconspicuous and difficult to distinguish.

4. They should afford rapid and covered communication from each work or part of the defensive line to the rear, so that supports may be brought up with the utmost rapidity.

41. *General Character of the Supporting Points.*—Along certain parts of the defensible ground, where a good field of fire in the required direction can be obtained, will be constructed lines of infantry parapet with cover in rear, connected by covered ways, perhaps with each other and certainly with the rear. On suitable positions for artillery fire will be constructed the emplacements for the guns, also with communications to the rear. The selection of both these infantry and gun positions will be governed by the four main principles stated above.

To permit of full scope for the defender's rifle fire, all that is needed is a simple parapet to fire over. In trace this should follow the contour of the ground, and should therefore seldom be straight, and never on any geometrical plan. (See paragraph 13.)

It is necessary, in order to cover the field of fire completely, that the works be traced along the military crest itself or simply on the gently sloping ground following approximately the contours of the ground.

This disposition presents one great advantage; which is, that it does not offer to the eye of the enemy's observer any geometrical form betraying the work of man. No other plan will answer; the crest of fire, lending itself to all the changes of the ground, cannot be perceived, even at short ranges. Moreover, neither the trace nor the execution will be complicated.

42. *Redouts* cannot generally be used in situations exposed to artillery fire unless they can be so arranged that they cannot be recognized as such from the enemy's artillery positions. A favorable site is one which commands the ground around it to effective rifle range and is not visible from artillery ranges.

In preparing a defensive position, if sites meeting the foregoing conditions can be found on which redouts can be built to flank the adjacent trenches, they should by all means be built. Redouts in good position *in rear of a line* form valuable supporting points.

The Fort Riley redout (Fig. 205, E. F. M.) and the Russian and Japanese redouts (Figs. 1 and 2) are excellent types of a modern redout. (See paragraphs 102-4.)

In speaking of the Shanlantzu redout, Major Kuhn states: "In my judgment, it has the best profile and trace of any seen during the war, affording good cover, small

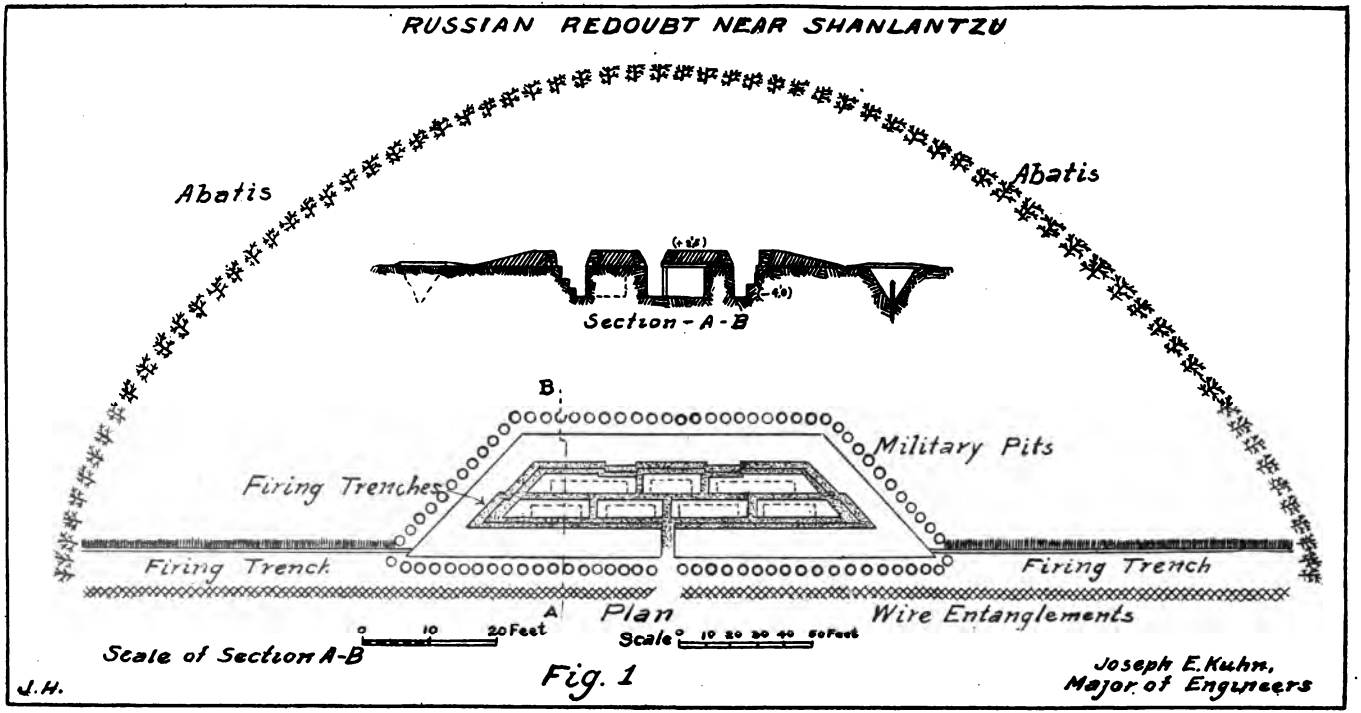
artillery target, and strong frontal fire for infantry. The Japanese constructed a somewhat similar redout near Kangpienhsien and it is surmised that the Shanlantzu redout served as a model.

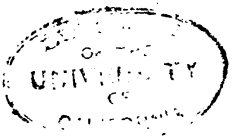
"The polygonal trace with a broad front and shallow depth appears to best meet the requirements for a closed work under modern conditions, affording a strong frontal fire and a minimum target to the artillery. While the reduction in depth of closed works imposed by the searching power of artillery reduces the volume of flank fire and diminishes the value of such works in an extensive fortified line in flat country, forts and redouts have not lost all their importance and are still needed to afford points of support to a defensive line. The employment of machine guns, moreover, enables small works with short flanks to deliver a volume of fire which makes the size of works and their garrison a matter of minor importance.

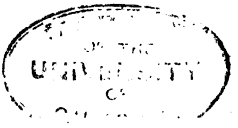
"It is to be noted that none of the forts or redouts provide for the emplacement of artillery in their interiors. The artillery was placed either in the line of the trenches connecting the forts and redouts, or, more generally, in a retired position several hundred yards in rear of the front line.

"It is only in perfectly flat and unbroken country that redouts need approximate the type forms of closed works shown in text books. In ordinary diversified topography many points will be found which, with simple trenches, cover for men and ammunition and good approaches, will fulfil the requirements of redouts without the use of closed works."


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RUSSIAN REDOUBT NEAR SHANLANTZU
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B
Military Pits
Firing Trenches
Firing Trench
Firing Trench
A
Plan
Wire Entanglements
Scale of Section A-B
0 10 20 Feet
Scale 0 10 20 30 40 50 Feet
J.H.
Fig. 1
Joseph E. Kuhn,
Major of Engineers





43. An *intrenchment* is a shield; its object is to make the defender safe, either when at rest or when in the firing position, against the action of the enemy's projectiles; its profile is therefore dependent upon the armament in use. It must necessarily vary with that and undergo a parallel evolution.

The profile depends furthermore, especially for intrenchments made on the field of battle, upon the time that the defender can give to their execution. This time will always be short, first, on account of the fatigue that can be imposed upon the troops and which must be reduced to a minimum; and second, because it will not usually be possible to determine exactly, very long in advance, the ground of the struggle.

44. *Effect of Weapons.*—The rifle and machine gun shoot a bullet whose penetration in earth varies according to the arm, the distance and the nature of the soil, from 24 to 40 inches. This last penetration hardly applies except to clay at very short ranges. Thirty-two inches can be considered as the normal maximum.

Shrapnel from field guns fired with a time fuse has no effect upon intrenchments which have a sufficient thickness to resist a rifle bullet. It can only have effect upon the defenders when the latter are firing. It is powerless when the men are resting behind the parapet, either seated or lying down with their backs to the mass or protected by it under the slope of about 1 on 4.

The same shell fired with a percussion fuse penetrates rather deeply into the earth of a recently constructed parapet when the projectile falls upon the exterior slope. Upon bursting it may form craters as large as 60 inches in diameter and 20 inches in depth. But when the projectile falls upon the superior slope, it

cuts out a furrow of not more than 6 to 8 inches in depth at the most, and carries away but little earth. In other words, it ricochets. Such shells fired against men placed upon the banquette of an intrenchment produce but little effect. At 2,000 yards it can hardly be hoped to get more than one man wounded for every shell, even with a perfectly regulated fire. . If the men are seated or lying down with their backs to the parapet, the result is practically nothing.

In general, high explosive shells from field guns produce no effect upon the unprotected personnel unless they burst very close to the object. They therefore require very great accuracy of fire. Fired against earthen parapets in which they can enter, these shells give quite a considerable effect, but the complete destruction of this class of works can only be obtained by a prolonged fire, regulated with accuracy, which will always necessitate a relatively great expenditure of ammunition. The personnel sheltered behind these parapets will suffer but little. Those shots alone which burst at the crest will produce serious effects. But these shots must be considered as altogether accidental, however well regulated the fire may be.

Shrapnel from siege guns fired with a time fuse has great efficiency against troops without cover up to a range of 7,000 yards for guns and 5,000 yards for howitzers. But as soon as the personnel is materially sheltered the effect of these shells becomes very small, even with plunging fire, and can be completely nullified if the defenders protect themselves by light roofs such as hurdles covered with from 4 to 6 inches of earth, or by means of thick planks. Under these conditions the greater number of balls and pieces of shells are stopped. Fired with per-

cussion fuses against obstacles and accessory defenses, shrapnel has an effect very inferior to that of high explosive shells of the same caliber.

Like projectiles of small caliber, those of large caliber ricochet when they are fired so that the angle of fall is less than 17°. The ricochet can also be produced when the angle of fall varies between 17° and 30°, depending upon the initial velocity and the nature of the soil. When the shell ricochets, it explodes in the air, and then produces very small and altogether uncertain results.

When shells of large caliber are employed against a parapet, the shots which strike the crest are very efficacious against the troops sheltered behind it, but, as with projectiles of small caliber, these shots will always be altogether accidental, even with a very well regulated fire.

Practically all of the above effects were obtained in the test of the field redout at Fort Riley in 1907 (fig. 205, E.F.M.), where high explosive shells from field and siege guns, and siege howitzers were fired at the work; which has a triangular profile and low command. Practically the only shells which penetrated the parapet and splinter-proofs were those of the 7-inch siege howitzer. (See Major Kuhn's comments, par. 46.)

45. *Profiles.*—From the above discussion on the effect of projectiles, the conditions which a good profile must satisfy are apparent.

The exterior slope of the parapet should have an inclination of not less than 1 on 5. This corresponds to an angle of about 11°, and the mean value of the angle of fall of projectiles from the present field guns is taken as 6°. With this slope, projectiles fired with a service charge from a field gun will nearly always ricochet. This

gives the personnel almost complete protection from field guns fired with percussion fuses.

To make a parapet proof against rifle and machine gun bullets and shrapnel balls, a thickness of 32 to 40 inches is sufficient. Thus behind a parapet 32 inches thick with an exterior slope of 1 on 5, the defender is practically altogether sheltered from rifle and machine gun fire and from projectiles fired with a service charge from long range pieces. Certain accidental shots on the crest alone can injure him.

It is apparent that the profiles given in the manuals do not satisfy the above conditions in regard to the exterior slope. This is usually the natural slope of loose soil, or about 1 on 1. Every shell striking the exterior slope will penetrate the mass of the parapet and produce therein considerable effect. These profiles therefore ought to be modified in this regard and ought also be modified in other respects.

Having determined the means of sheltering the defender from the projectile with a flat trajectory, the next consideration is to afford protection from high angle fire. This fire will be executed most frequently against the intrenchments by means of high explosive shells, and their powerful effects are well known. But, in order that these effects may be produced, it is necessary to hit the trenches, that is to say, the fire must be perfectly regulated. It is manifestly impracticable to try to shelter the men under great masses of earth in intrenchments on the field of battle. It can no longer be attempted even in the intrenchments constructed in a line of investment; and, as a general thing, endeavors should only be made to render the adjustment of the enemy's fire as difficult as possible.

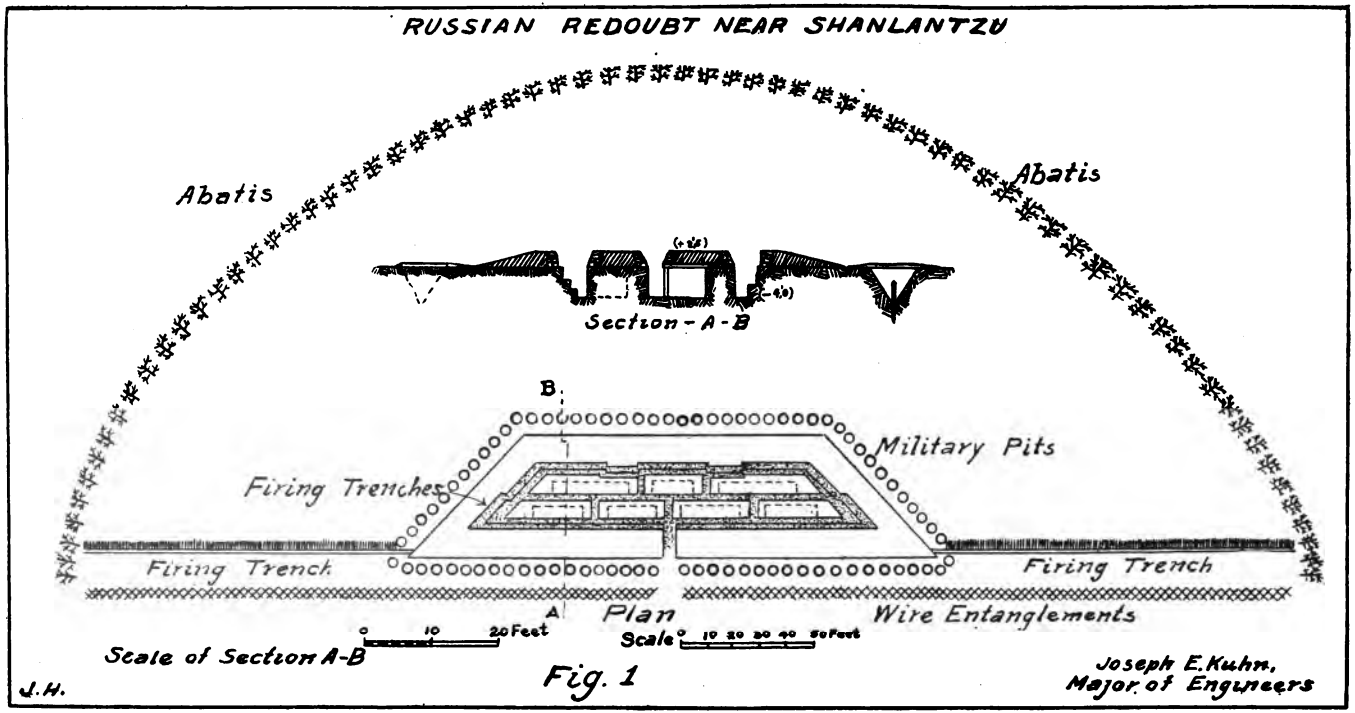
In consequence, the relief of the parapet should be reduced as much as circumstances will permit, and every means possible should be employed to render the intrenchments invisible at a distance (see paragraph 63).

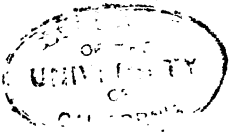
In order to reduce the chances of shrapnel or shell fragments entering the trench, it should be as narrow as practicable. The earth for the parapet can be obtained by deepening the trench. It may be necessary to sit close to the parapet in order to avoid the projectiles, and the parapet will afford protection in proportion to the steepness of its interior slope. It should be vertical if the earth will stand at that angle. Most soils will stand a short time in vertical cut, and if there is time for the earth to break due to weathering, there should be time to revet it at the desired slope.

A good intrenchment must therefore satisfy the following conditions in regard to its profile:

A relief as small as circumstances will permit; a parapet limited on the outside by a single gentle slope of about 1 on 6; a narrow trench, interior and reverse slopes as steep as practicable, replaced even, if possible, by vertical faces. It will be noticed that the thickness of the parapet, which had to be thought about when the exterior slope was steep, no longer comes into consideration when the latter is replaced by the prolongation of the superior slope. Furthermore, it is not even necessary to begin the exterior slope of 1 on 6 at the crest unless in exceptional cases when an increased relief to the parapet is necessary. Quite frequently it can be made with a flat surface practically parallel to the ground from 32 to 40 inches in thickness. This will protect a little more against rifle bullets, and will not create any sensible dead angle in front. It will also be more convenient for the de-


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Firing Trench
Firing Trench
A
Plan
Wire Entanglements
0 10 20 Feet
Scale of Section A-B
Scale 0 10 20 30 40 50 Feet
J.H.
Fig. 1
Joseph E. Kuhn,
Major of Engineers



little support from other sections, and yet, notwithstanding all that, it managed to hold out almost a month. Its length was about 600 yards and its garrison, one company of 200 men, or one man per 3 yards. Each man was protected on the sides with sand bag traverses and provided with head cover. A small cave was made in the wall at the bottom of the trench for keeping a supply of cartridges. The parapet was of earth 2½ feet high and 7 feet thick and well concealed with sod. (See par. 108.)

46. Some form of *head cover* should be provided, otherwise the defenders would be absolutely prevented from manning the parapet for firing purposes, by a heavy fire of musketry and shrapnel. For different forms, see E. F. M., par. 13.

A good loophole should not be visible; from a distance, it should blend into the parapet, which can be secured by adding earth in front and at the sides; the opening of the loophole should not project on the sky over the outline of the breastwork. Generally speaking, the construction and masking of loopholes constitutes a very delicate work requiring great attention. The opening should be masked.

A notched parapet is shown in fig. 10, and the protection afforded a man firing is indicated. (See par. 109.)

In the Russo-Japanese War at Port Arthur, a loophole cover (a light splinter-proof over the loophole) was found necessary to protect men firing, from shrapnel. This is shown in fig. 9, and an enlarged section, in fig. 11. (See par. 110.)

Loopholes should not be at intervals less than one yard, to avoid weakening the parapet.

When the head cover is not considered advisable, a substitute consists in providing sand bags stored in the

trenches. When the moment for opening fire arrives, each soldier can lay a sand bag upon the parapet, practically parallel to the direction of his fire. This gives an improvised head cover which is movable and which has not served the enemy's artillery in discovering the work, and now plays its part in the protection by almost completely sheltering the head of the marksman. Some bullets may go through it perhaps, but it will stop a great number to such an extent that the vulnerable surface of the man behind it will be very materially reduced.

General Ian Hamilton states: "From Majuba time onwards I have always held the opinion that loopholes double the value of any cover, and all I have seen since has tended to confirm me in this view. Even during an attack the soldier can usually find cover for his body, and if not, he can rapidly extemporize it with stones or spade work. Under such conditions he is at least on an equal footing with an adversary who has to show his head over the straight line of a conspicuous breastwork before he can fire. Indeed he is far less visible, and thus less vulnerable to distant artillery fire. To give a defender that indisputable advantage which is necessary to counteract the depression of having to wait whilst the enemy is advancing, he should be provided with a loophole, or head cover of some sort. Then, and only then, will the average soldier retain confidence enough to use cool, deliberate, aimed fire amidst the showers of shrapnel and rifle bullets which whistle and sing past his ears. Otherwise he fires hastily and fires high, the instinct of self-preservation impelling him to 'loose off' as quickly as possible. and get his head those twelve inches lower which will give him, at least momentarily, immunity from deadly danger."

Major Kuhn states: "As was to be expected, the material damage inflicted by artillery on field works proved a negligible quantity, but some form of head cover was shown to be necessary to give protection and confidence to the troops when long exposed to shrapnel fire.

"When loopholes were used in field works they were made most frequently of sand bags or sod. When available, brick and stone were also employed.

"At Liaoyang and Haicheng the Japanese trenches had little mounds of mud on the superior slope. In the absence of more suitable material these mud mounds afforded a simple and fairly effective form of head cover."

47. A *background* for the heads of the parapet defenders would usually be provided by the natural ground in rear, by placing the parapet somewhat forward of the crest of the hill. Where this cannot be done, it may be necessary to provide it artificially.

In order that high explosive shells may not injure the defenders who are manning a parapet or sitting close behind it, it is necessary that there should be nothing in rear to catch the shell and explode it or act as a stop-butt, for in this case the back-blast or all-around effect would cause loss. The ideal arrangement would be to have the parapet in such a position that all shells just missing the crest would pass clear away into space. But this could very seldom be arranged, as it would usually entail tracing the parapet on the sky line when viewed from the enemy's position, so that the defender's heads would be conspicuously visible. It should, however, always be arranged so that there is no steep rising ground or bank close behind the parapet.

For this reason most redouts or forts are regular shell

traps because of the parados, designed to protect the defenders of the gorge of the redout from reverse fire.

48. *Arrangements for Fire to the Rear.*—In the present day regular closed redouts are not usually required, so protection to the defenders of the gorge is unnecessary. If it is desired to provide a firing line facing towards the interior of the fortress, it should be at a distance off, and probably on the reverse slope of the hill, or in some other place hidden from the front.

If a closed redout is constructed, its gorge trench should have a double parapet; the front one, serving as a parados, should be kept low and used as a firing line to command the interior of the work, in case the enemy gets in over the front.

If the trenches are in such a position that there is a field of fire to the rear, they may be arranged for fire in that direction. The profile shown in fig. 12 may be so arranged by loopholing the reverse parapet.

49. *Overhead cover* of some sort should always be provided unless the exigencies of time prevent it. It is not, however, necessary that this shelter should be of a very massive or elaborate description. It is very doubtful whether it would ever be necessary to make the cover of a sufficient strength to resist bombardment. It is evident that if the shelter is made completely underground and the earth above it is made to exactly resemble the surrounding ground, it will be impossible to locate its position, or to drop successive shells upon it. The utmost it would have to fear would be a chance hit.

Splinter-proofs should satisfy the following conditions:

1. They must not cause breaks in the firing crest, for they would then necessitate an increase in the linear

development of the trenches for a given number of marksmen, and consequently would increase the labor by a considerable per cent.

2. They must be capable of construction after the trenches are built, without requiring any considerable readjustment of the work already done. This condition will be very useful when it is not possible to determine upon the time available for fortifying a position, when there are not a sufficient number of workmen to make both parapets and shelters at the same time, and when it has not been possible to get together the necessary materials for the building of these shelters at the moment when work on the trenches can be commenced.

3. They must permit the sheltered men to come out rapidly, in order to get to their fighting positions behind the firing crest.

4. They must not cause any projection above the parapet, which would immediately disclose its presence.

The shelter may be small in area; it is only required to accommodate the men in the firing line, for the supports should be in another shelter in rear. If time and materials do not admit of covered-in shelters being provided, a deep, narrow trench will give fair security. If the earth admits, it may be recessed on the side next the enemy, as in the Boer trench (fig. 11, E. F. M.).

Fig. 12 shows a form of splinter-proof which may be constructed after the trench is completed, and gives complete protection to men firing. (See par. 111.)

In fig. 13 is shown a splinter-proof constructed in the trench shown in fig. 3, which fulfils the above conditions.

Fig. 14 shows a splinter-proof which can be constructed either during or after the construction of the

trench shown in fig. 3. By deepening the trench as shown by the dotted lines, two ranks of men may be sheltered sitting, facing each other; see par. 112. (For other forms see fig. 10 and E. F. M. figs. 34-43.)

When shelters are constructed immediately in rear of the works, in order to prevent their being hit by shots aimed at the firing trenches, they should be separated from their firing trench by at least three times the mean probable error of the pieces having the greatest error. This error may be assumed as about 50 yards for pieces in use today. Therefore shelters must be established at least 150 yards from the work, unless local conditions and the form of the terrain permit this distance to be reduced. But by judiciously placing the shelters a distance of even twice the probable error in rear of the firing crest; that is, 100 yards, the probability of being struck by shots aimed at the crest will be very small.

Another method often preferable, of guarding the splinter-proof against shots aimed at the trenches, consists in placing it a little to the rear and outside of the flanks. It is evident then, in this case, that if the necessary precautions are taken to render the shelters as invisible as possible, they will not become the object of special fire, and they can be placed much less than 100 yards to the rear. In both cases it will become necessary to establish covered ways between the shelters and the trenches. This latter will most frequently be possible only in sieges.

The *thickness* of overhead cover for splinter-proofs should be from six to eight inches of earth on a support of brush or poles strong enough to hold it up. For bomb-proofs a minimum thickness of six inches of timber and three feet of earth is necessary against field and siege

guns, or twelve inches of timber and six feet of earth against howitzers and mortars of a heavy siege train. The essential thing is the thickness of the earth layer, while the beams serve only to support the earth.

In determining the *area* of overhead cover to be provided, allow six square feet per man for occupancy while on duty only, or twelve square feet per man for continuous occupancy, not of long duration. For long occupation eighteen to twenty square feet per man should be provided.

50. *Lookouts.*—In all firing trenches provided with overhead cover, some form of lookout must be provided to enable the occupants to keep informed concerning conditions and movements in their immediate front. These lookouts will ordinarily be arranged in a manner similar to loopholes with the extra condition that they should give as extensive a view over the foreground as possible.

Major Kuhn, in describing the Japanese lines north of Mukden, states: "No projections are allowed above the fire crest excepting only the lookout stations, which are located on the most commanding points a few yards in rear of the fire trench. These are made bombproof and kept as low as possible consistent with having the sighting slit overlook the foreground."

51. *Magazine accommodation* is not necessary. Rifle ammunition is best placed in recesses distributed all along the front, close to the parapet, and these would be replenished from an intermediate depot in rear of the works. Artillery ammunition will be stored near each gun emplacement.

52. The trenches and shelters should be in *short lengths,* particularly if oblique or enfilade fire is to be anticipated. This will facilitate their adaptation to the

ground. Lateral communication need not be sacrificed by this, as the trench may continue round a piece of natural ground left as a traverse. If possible, the length of any distinct independent piece of trench should be such as to be suitable to be garrisoned by a distinct unit, such as a company, platoon, section or squad.

53. In *locating a line of trench* it is important:

1. To avoid a sky line.
2. To occupy the military crest or line in advance of it.
3. To preserve communication under cover with the rear.

The selection of the exact position of infantry trenches, how far forward or backward, is a matter of considerable importance. If the defensive position is on a hill or ridge it will generally be difficult, if not impossible, to find any spot at or near the top where all the ground in front, both near and far, may be seen, except in a position greatly exposed to view and fire; especially that of the enemy's artillery located behind an opposite ridge. It may also often be difficult for the artillery of the defense to sweep the slopes in front of the trenches, without using direct fire in an exposed position. (See par. 18.)

Often the best situation will be at the bottom of the hill slope, at or near its junction with the plain in front; from these a grazing fire can be brought over the plain, and trenches in such a position can probably be well concealed, and it may be difficult for the enemy's artillery to reach them.

It may be advantageous to give two lines of trench, one low down the hill, as above, and another firing over it at the distant ground from the top of the hill. The lat-

ter may, if the top of the hill is wide enough, be drawn well back from the actual front crest of the hill, and this will generally assist invisibility (fig. 15). This retired position would have a further advantage in that its supports could be kept close up in rear on the reverse slope of the hill, and the ground in front of the trenches could easily be swept by the artillery of the defense, located in a sheltered position behind a hill or ridge in rear.

If there is timber near the top of the hill, the line may be located in it, so as to have a good field of fire and yet not be exposed to artillery fire directed at the front edge. (See par. 62.)

54. *Field of Fire.*—The question as to whether the trenches should be located so as to control the ground at long and mid range or at short range is important, and no single rule can be laid down for all cases, as the proper solution will depend not only upon the topography of the site, but also upon the relative proportions of artillery and infantry of the defense. If it is impossible, on account of accidents of the ground, to keep the enemy under fire from 1400 yards in, it would be advisable to use the artillery so as to force an early deployment, and by lines of skirmishers in advanced trenches, so situated that the men can be withdrawn without difficulty or without masking the fire from the main position, delay his advance as much as possible, reserving the defense from mid range in for the main line.

It will seldom happen that the entire field of fire to the limit of effective range can be completely swept from any position that can be selected. A position should be sought which reduces the dead spaces to a minimum in number and extent; and, if possible, advanced or auxiliary trenches should be located to sweep them. If the ground

is open to 1,000 yards or more, the long or mid range is more important than the short range, for an effective fire on the enemy while he is advancing from 1200 to 200 yards range will almost certainly put him out; or, if by any chance, he arrives at 200 yards in condition to keep on, little can be attained by holding him under fire from 200 yards in, and a retirement is in order, unless obstacles exist. In both cases, the advantage of dead space in the close foreground is more apparent than real, and the main trenches should not sacrifice command of more distant ground within effective range, in order to sweep the foreground. Such dead ground must be commanded at night or in thick weather by trenches detached or in flanking relation.

On the contrary, if an enemy can approach under cover to mid range or less, there will scarcely be time to stop him by fire alone, and obstacles are desirable at close range, which must be commanded by fire. The trenches, in such cases, must be advanced to cover the close foreground, and if necessary another line in a different position established to sweep the more distant ground.

55. *Communication with the Rear.*—There is one considerable difficulty attending the location of lines of parapet in a forward position low down a hillside, and that is in the provision of concealed means of access to them and of shelter for the supports. Where the works are hastily thrown up in anticipation of an early attack, it will be hardly possible to provide for these at all, and the use of works in such positions should in such circumstances be avoided as far as possible. If the ridge is intersected by ravines or covered with growth through which men could move under cover, the trenches at the foot of the slope can be easily reinforced and should be constructed.

Where such works are absolutely necessary, and also in cases of other advanced isolated works where covered approaches cannot be constructed, the defenders, who must be in more than the usual strength, must take their posts under cover of darkness, and must take with them food, water, and ammunition for the whole day; for it will be impossible to reinforce them under fire or to relieve them except at night.

Where, however, the works are constructed some time before an attack is expected, oblique approach trenches can often be provided, and this should be done wherever possible, but the configuration of the ground may sometimes forbid it. Fig. 16 shows a typical arrangement of approaches and communications from the support to the firing trenches. Fig. 17 shows a section of communicating trench; if the enemy's fire is all from one side but one bank is needed. (See paragraph 113.)

There is little need for concealment of these communicating trenches, for, if they are deep enough to prevent the enemy from seeing whether anybody is passing through them, he cannot afford to bombard them on the mere chance that there may be somebody there. It is only to prevent their betraying the position of the firing trenches that it is advisable to have them inconspicuous. They should be laid out so as to take advantage of all accidents of the ground, both to save labor and to secure invisibility.

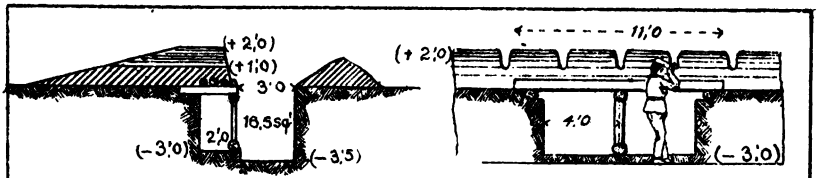
56. *Cover for Supports.*—The provision of suitable cover for the supports is a most important matter. The best place is on the reverse slope of a steep hill. When good natural cover does not exist, it may be necessary to provide artificial splinter-proof shelters, kept low and well

concealed, or even in extreme cases to provide bomb-proofs, but the latter would only be necessary where the site was most exposed and unsuitable for defense.

The supports must be protected against the fire of the artillery up to the moment of their intervention, and placed so that, if necessary, they can reinforce the firing line or make a movement to the front, without having to suffer greatly. This result will be obtained by placing them in the cover trenches constructed at least 100 yards in rear of the crest of fire, either opposite the intervals between the works or else upon the flanks; and by placing part of these trenches prepared for firing, so that they can cover the intermediate terrain well with their fire without leaving the trenches; or by abandoning the trenches in order to make a move to the front. Under these conditions the reinforcement of the line of fire will be made, if there is occasion to make it, simply by prolongation; whilst that of the counter attack, setting out from a point very close at hand, will very quickly leave the zone bombarded by the enemy's artillery after he elevates his fire, and will act with all the desirable suddenness.

Depending upon the terrain and the tactical circumstances, the cover trenches of the units in reserve can be formed either into a single line or in echelon, corresponding each to about one section. They should not be placed one behind another, as that would increase their chances of being hit. When they can be prepared with light splinter-proofs of the type mentioned in paragraph 49, two men per yard of length can easily be sheltered. The development will be still less with the more elaborate type of splinter-proofs.

Major Reichman states: "The shrapnel is a most ef-



Profile Fig. 10. Elevation

Notched Parapet with Splinter-Proof.

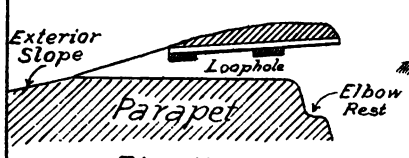


Fig 11

Loophole Cover

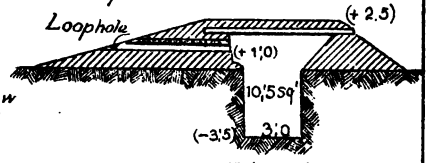


Fig. 12

Splinter-Proof

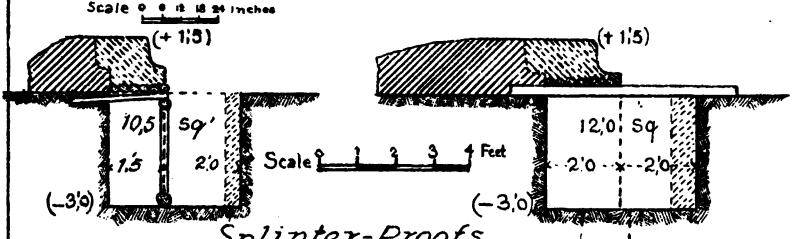


Fig 13 Splinter-Proofs Fig. 14

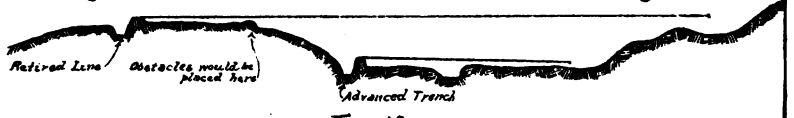


Fig. 15

Trenches retired and advanced

Infantry Positions

Showing communications with supports.

Fig. 16

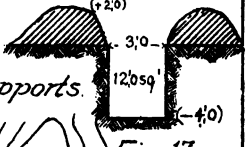
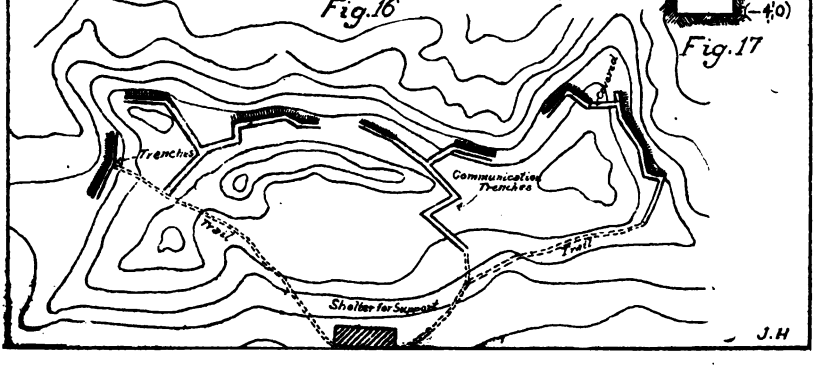


Fig. 17



fective and deadly projectile, and in combination with its long range, compels all to hug cover. The side that stands on the defensive must have very substantial cover if it wishes to avoid murderous losses, and at the longer ranges with the steep angle of incidence of the shrapnel the reverse slopes of hills offer little protection. It is therefore necessary that not only the firing line on the front slopes but the reserves on the reverse slopes, be protected by suitable cover."

57. The *drainage* of defensive works that are to be occupied longer than a day is of great importance and should be provided for, as otherwise the trenches and works may be so flooded by storms as to become untenable. The drainage problem is difficult in deep trenches; pumping may have to be resorted to, or seepage pits dug. All surface drainage into trenches should be cut off.

58. *Telephonic communication* should, if possible, be provided between the positions of the supports and each of the principal infantry trenches or groups of trenches, and also to the post of the section commander in rear. (See paragraphs 13, 24 and 76.)

59. *Obstacles.*—With an open field of fire, entrenched troops with magazine rifles and plenty of ammunition do not require the aid of obstacles to enable them to stop the most determined attack. Still, they would always add considerably to the strength of a position, and there may be places where obstacles are required; namely, where the work is retired behind the military crest of a hill so that the field of fire is short, or to delay troops at certain points where a heavy fire cannot be brought to bear on them, such as at the passage of a bridge or ford, in a defile, etc.

Obstacles are designed to protect the works from sur-

prise and to reduce the momentum of attack by breaking up the enemy's formation, and holding him under the accurate fire of the defense. They should be invisible from the direction of approach, should be difficult to destroy, and should afford no screen or cover to the enemy.

Obstacles should be placed at such a distance in front of the parapet that shots directed against it will not seriously injure them. The fire of guns is more efficacious against obstacles than that of howitzers and mortars; and their probable mean dispersion is about 30 yards. Consequently, obstacles ought to be established from 90 to 100 yards from the parapet, and never less than 60 yards, unless covered or screened.

This distance between the trenches and obstacles which the effect of the artillery fire requires, is also demanded by moral considerations. If the obstacles are placed too near the trenches the defender of the parapet runs great risk of becoming demoralized by the advance of the assailant, whom his fire cannot stop, even before the enemy reaches the obstacles. These obstructions will then be useless. They should always be so placed as not to interfere with the execution of counter attacks. They should usually not be placed at a distance from the firing trench greater than 400 yards, in order that the defenders of the trench may not be under artillery fire when the attacking troops reach the obstacle.

If on the line, they are in the ditch, if there is one, or are employed to close intervals, and are flanked or enfiladed by adjacent works.

The high wire entanglement is the most generally useful of all obstacles, because of its effectiveness, the rapidity of construction, the difficulty of removal, the comparatively slight injury from artillery fire, and its in-

dependence of local material supplies. In wooded country abatis or slashings would generally be used. (See E. F. M., paragraphs 49-59.)

60. *Clearing the foreground* in front of the infantry parapet is important, but of course it will generally be impossible to get rid of all the cover within effective range of modern rifles. As much as possible should, however, be done, beginning near the works and proceeding outwards. If possible the clearance should extend to at least 800 yards from the parapet. The demolition of every house or village in front of the defender's works is not so important nowadays as it used to be; the attackers will not be able to use the buildings as positions for their infantry, as a few rounds of high explosive shell would bring them down in ruins on their occupants. They should, however, be removed if concealment could be obtained in rear of them for the attacker's columns.

61. *Houses or villages* which exist within a defensive line will seldom be of any use from a defensive point of view. If occupied they would offer most easy targets for concentrated artillery fire, and the destructive effect on buildings of modern high explosive shell is so great that they would bring ruin on any troops within them. It would generally be safe to ignore them altogether, as the reasons which make them unsuitable for the defenders to occupy would also make them objects of little temptation to an attacker, who would similarly be unable to hold them under the defender's fire. If it were really necessary to deny to the attackers the ground occupied by buildings, it would be best to put the defenders in trenches outside, well clear of splinters or fragments of stone, but in a position to bring fire over the ap-

proaches to the buildings. In places, however, where artillery could not be brought to bear, a group of strong buildings could be easily made into a strong defensive position. Isolated walls or walled enclosures without roofs, if thick enough to resist rifle fire and shrapnel bullets, are useful, for they cannot be damaged except by a direct shell hit, and even then only a short length will be blown down. They afford, however, a good target. (See E. F. M., paragraphs 60-63.)

62. *Woods* are not generally very useful under modern conditions. If it is known that the front edge is held, so good a target is afforded that a very heavy fire can be concentrated on it. The interior of a wood certainly gives concealment, but great labor is involved in preparing a defensive position there and forming a field of fire, obstacles, and communications. Such a position gives no fire outside the wood to the front, unless the wood is on a steep slope; in which case a line might be located in the wood and have a good field fire to the front. If a wood is in front of the defensive line, its rear edge should be entangled and positions taken up from which a fire can be brought to bear on troops issuing from it. Generally speaking, a wood in a defensive position is a source of weakness, and works should be arranged if possible to bring a heavy fire over the ground in front of them so as to prevent the enemy from getting into them. It may sometimes be possible to have the front line of the woods, or a position just outside the front edge, prepared for defense, with the defending troops kept concealed in rear, and only brought up when an infantry attack develops, and the enemy's artillery fire must to a considerable extent cease. Communications will in such cases be necessary.

63. *Concealment.*—Fire, when its effect can not be seen or learned, is almost certain to be ineffective, and may be merely a waste of ammunition. If the target cannot be distinctly seen, it is correspondingly difficult to ascertain the effect of fire upon it. Concealment, therefore, offers greater protection than any other single feature, and every effort should be made to obtain it. As a result there is no longer such a thing as a normal type of trench; for the form which might be best suited to one locality, owing to color of soil, configuration of ground and character of vegetation, might be very conspicuous and wholly inadmissible at another.

Concealment will have to be secured in each case according to the conditions of the site at the time. It is obvious that a trench in a landscape of green would have to be differently treated from one at the same place in the late fall or early spring; the color of the earth might be very conspicuous against green, but difficult to see against the yellowish brown of the same vegetation when dead; the similarity of color would be stronger still in a plowed field.

One of the best means of concealment is the suppression of the exterior slope. With the profiles given in our manuals, especially when the slopes are carefully finished, the parapet is visible at a great distance by the simple difference in lighting of the exterior and the superior slopes, and of the adjacent terrain. With a very gentle slope of 1 on 5, or better, 1 on 6, that is to say, a continuation of the superior slope, the difference in lighting between the two surfaces is suppressed, and furthermore, a surface is made, which, leaving the general surface of the earth with a very slight angle, has a luminous value approximately equal thereto.

Objects projected against the sky are much more distinctly seen than when viewed against a background, other conditions being equal, and any location which will bring the trenches or guns on the sky line should therefore be avoided. It should be remembered, however, that the sky line varies according to the observer's position, and that the one of importance is that from the enemy's point of view. A distant background tends to render a trench more conspicuous than one close at hand, and a trench blending with its immediate vicinity, may be readily recognized, if projected against the different shade or degree of color or different vegetable growth of a distant hill. Where the condition of securing a proper field of fire forces the trench into a location in which sky line or background tends to make it difficult of concealment, it may be rendered inconspicuous by an artificial background or a slight screen in front. It should always be borne in mind that a man, close to a screen of vegetable growth, can see what is on the other side better than a man much farther away; and that if he is immediately behind it, he may have almost an uninterrupted view, even though it be thick enough to form at a distance a nearly complete bar to vision. In constructing artificial backgrounds or screens, care should be taken to have them appear as natural features of the landscape, otherwise they will simply serve as trench markers.

Invisibility is ordinarily increased by keeping the parapet as low as possible. Every foot that the command is increased makes it harder to conceal the earth thrown up. In endeavoring to keep the parapet low, great caution must be observed not to put it below the height demanded by a proper field of fire over the fore-

ground, and this can be determined only by putting the eye at the same height that the soldier's eye will be in firing.

Invisibility is also increased by causing the parapet to blend in with the landscape as much as possible; this is effected by various means, such as avoiding all sharp angles, causing the ends of the parapet to fall away gradually and generally avoiding any sudden changes in direction vertically, covering the earth thrown up, if conspicuous, with material which will conceal its color and cause it to resemble immediate surroundings, etc.

It is more important that the trench be screened from artillery fire than from infantry fire, hence efforts should be made to render it inconspicuous from the position which will probably be occupied by the enemy's guns or observers. If there is opportunity, an officer should be sent to these points to find whether he can, with a field glass, readily see the trenches or not; and, if they are quite discerned, to make note of the features which render them conspicuous, whether color, shape, projection against sky or other background, etc. It is more important to conceal the trench against the enemy's artillery than against his infantry, because the artillery can bring a shower of projectiles upon it from such ranges that the infantry rifle is helpless in reply, while against infantry fire of the attack, which must be delivered in the open, the trench should have the advantage. If the trench can be made inconspicuous at both long and short ranges, so much the better; but officers should remember that the appearance at 100 yards may be quite different from what it is at 500 or 1,000 yards, and that within 400 yards appearance matters little, as the enemy in attack is then

too close to change his formation to conform to what he may then see.

Major Kuhn states: "At Nanshan the parapets of the Russian trenches were relatively high and prominent. In fact, the Russians made no attempt at concealing their trenches in their positions preceding the battle of Liaoyang, and their works were conspicuous on the bare hillsides. Even at greater distances, the freshly turned earth and prominent profile of the parapet plainly marked their location. At Liaoyang and subsequently, attempts at concealment by covering the freshly turned earth with sod and by adopting flatter slopes for the parapet, became manifest.

"When practicable the Japanese always employed artificial concealment for their trenches, covering the freshly turned superior slope with millet straw, bean vines, or kaoling stalks gathered from adjacent fields, or even planting a row of kaoling stalks in an upright position.

"In the matter of concealing their works the Japanese took infinitely more pains and displayed a far greater skill than the Russians."

Major Judson states: "Thus far I have dwelt upon the principle of dispersal. (See paragraph 13.) The other principle emphasized in this war was, of course, concealment. By every artful device the position of the defensive units must be kept from the enemy. The works must be of slight profile or mainly sunken. Much earth must be carefully wasted out of sight of the enemy. New earth within range of his vision must be sodded, or planted with stubble, to resemble neighboring areas. Artillery positions must be located in rear of crests, villages

or woods. As a rule, rather than as an exception, artillery must fire over infantry.

"To secure concealment and a proper location and dispersal of field works, obviously no special rules can be laid down. In each case what is required is an application of a trained common sense to the particular problem offered by the terrain."

64. *Dummy Trenches or Parapets.*—In case *concealment* of the general position is not possible, deception must take its place. The trenches actually occupied must be so arranged as to afford concealment of the individual man, and dummy trenches, purposely made easily visible, may be arranged to draw the enemy's fire.

Dummy trenches should, if practicable, have head cover, not only to make them more conspicuous, but also to make it more difficult to discover whether they are occupied or not. They are better above and behind the occupied trenches, if the lay of the ground permits. The enemy will observe that fire comes from the direction of the dummies and will conclude that it comes from them. Fire directed on the dummies will pass over the heads of the defenders, a condition preferable to shots falling short, which would be the result of dummies in front of the occupied trenches.

It is obvious that dummy trenches should be placed at such distance from the real trenches as not to bring the latter within the fire which they may attract.

The Russians in Manchuria in some instances made a line by turning two or three furrows with a plow which looked at a distance like the parapet of a trench; and where they covered these furrows with grass, which soon dried, the effect of an imperfect concealment was strong.

CHAPTER V.

ARTILLERY POSITIONS.

65. *Low commands and inconspicuousness* are to be sought for in the location of artillery emplacements, and they must be suitable for pieces on traveling mountings. (See paragraph 18.)

Concealment of position is most desirable, whether artificial or natural cover is used, therefore sky line crests without cover are generally forbidden. It is quite as bad, if not worse, to take position on the reverse slope, where an enemy can easily range to the top, and then proceed to sweep the slope beyond. Without making the mistake of moving too far back, it is nevertheless advisable to make it from 100 to 300 yards, the ideal position being behind a crest of another similar height some distance in rear. The enemy would naturally be deceived as to the result of his shots going behind the first crest. To be sure artilley creates so-called "dead spaces" in taking such positions, but they must be cross-fired by units dispersed elsewhere. An intelligent dispersion of the units, moreover, diminishes the enemy's fire and increases his difficulties of adjustment. (See paragraph 15.)

In taking position behind a crest, a defilade of 15 feet is necessary for the concealment of the gun flash.

The maximum effective ranges of field and siege artillery may be taken as follows:

3-inch field gun	6,500 yards
4.7-inch siege gun	7,600 yards
6-inch siege howitzer	7,600 yards
6-inch siege mortar	5,500 yards

Major Kuhn states: "At Port Arthur the Russians made the mistake of placing batteries upon the highest and most conspicuous places, which became easy marks for the Japanese batteries skilfully located in the inequalities of the floor of the valley fronting the Russian hills. In the later stages of the siege the Russians became wiser and some of their later batteries were most skilfully located, depending upon indirect fire, which latter can now be very well controlled and directed."

66. *Form of Emplacement.*—No form of siege battery will give protection from howitzer or mortar shells; all that can be done is to surround the gun platforms with splinter-proof walls to keep out fragments of shells which burst outside the emplacement. (See figure 118, E. F. M.)

If the battery is in so retired a position, or so well concealed by intervening high ground, woods, etc., that it cannot be seen from any part of the besieger's position, and observation of fire on it is impossible, then it is hardly necessary to have even splinter-proof walls, for a shell could only be dropped in the neighborhood of the emplacement by chance. If, on the other hand, the emplacement was anywhere visible, these walls would form too conspicuous a target.

Emplacements for direct fire guns, which would be in positions visible to the enemy, would have to be concealed by sinking them into the ground, and having a background of trees or rising ground in rear. Invisibility for such pieces is a matter of supreme importance, provided, of course, that range and field of fire are not sacrificed.

Where the emplacements are liable to shrapnel fire, some form of cover for the detachments should be pro-

vided. This may, in the case of field defenses, consist of two deep pits close against the front parapet, one on each side of the gun, similar in principle to those in the ordinary type of field gun emplacement, but larger and deeper. (See figure 18.) Or overhead splinter-proof cover may be provided at the sides of the emplacements, or in the traverse, where such exists, between a pair of emplacements.

67. *Positions for Light Guns.*—It would not as a rule be necessary to provide any works for the light rapid-fire armament or for the field guns. The essence of the employment of pieces of this nature is surprise and mobility, so that there should be nothing that will mark the positions from which they will open fire. If any form of protection is required, field epaulments can be made when wanted.

Guns firing by indirect fire will be behind natural screens, such as a hill, woods, etc., and usually will not need a parapet for protection. If by any chance the enemy should ascertain their position closely enough to make it uncomfortable or dangerous, they can ordinarily be shifted to some other place without detriment to their own fire.

When engaged with direct fire, guns, even though provided with shields, will need some screen or protection. When the ground is soft and no natural cover exists, guns are best protected by being sunk in pits or placed behind epaulments. The smallest mound in front of a gun will stop the bullets which could strike the gun crew in great numbers, by ricocheting under the shields. A larger parapet could almost completely place the artillery under shelter from any percussive fire that the enemy would try against it. Moreover, in doing this the

artillery will not lose any of its mobility if it is well understood that it must not consider itself as any more anchored to an artificial cover than it would be to a natural one, which it certainly would not hesitate to make use of on such an occasion.

Figure 18 shows a type of gun pit with the caisson body alongside the gun. The pits on each side may be provided with splinter-proof cover of the type shown in figure 12, if time permits. (See paragraphs 111 and 114.)

Figure 19 shows a section through a gun pit for direct fire behind the crest of a hill. Figure 20 is a section through a gun pit for indirect fire.

68. *Indirect Fire.*—The distance that field guns using indirect fire can take position below the crest of a hill is shown approximately in the following table:

Ranges Yards	At 50 yds. Feet	75 yds. Feet	100 yds. Feet	200 yds. Feet	300 yds. Feet	500 yds Feet
1000				10	13	16
1500			10	19	26	38
2000		11	15	29	41	66
2500	10	16	21	40	58	
3000	13	20	27	53	77	
3500	17	25	33	66		
4000	21	31	41			

The following table will also assist in the location of field guns for indirect fire, and in determining the protection afforded by reverse slopes to supports and reserves:

ANGLES AND SLOPES OF DEPARTURE AND FALL OF SHRAPNEL.

From Field Guns.

Ranges Yards	Departure		Fall	
	Angle	Slope	Angle	Slope
500	0°32′	1/110	0°35′	1/100
1000	1°11′	1/50	1°27′	1/40
1500	1°59′	1/29	2°38′	1/22
2000	2°57′	1/20	4°08′	1/14
2500	4°02′	1/14	5°49′	1/10
3000	5°12′	1/11	7°41′	1/7.5
3500	6°29′	1/9	9°44′	1/6
4000	7°54′	1/7.5	12°03′	1/5
4500	9°28′	1/6	14°37′	1/4
5000	11°10′	1/5	17°26′	1/3.3
5500	13°01′	1/4.5	20°29′	1/2.8
6000	15°02′	1/4	23°41′	1/2.5
6500	17°13′	1/3.3	27°07′	1/2.2

The dispersion due to the explosion of the shrapnel shell increases the angle of fall of some of the bullets at 3,000 yards to about 18°, or 1 on 3.

69. *Expense magazines* for at least two days' supply of ammunition are required in the neighborhood of each battery or group of emplacements. They should generally be on the flank of the battery, conveniently close, and connected by a trench to give covered approach. Recesses or benches for a few rounds of ammunition should be provided in each emplacement.

70. *Means of access* to the emplacements, to enable the pieces to be brought in or taken out, is very necessary.

71. Every battery or group of emplacements requires an *observing station,* which should be on com-

manding ground whence all objects to be aimed at can be seen. They need not be near the battery if telephonic communication is provided. They should be as inconspicuous as possible. A type used at Port Arthur is shown in figure 21. (See paragraph 115.)

72. *Captive Balloons.*—In case there are many of the enemy's battery positions which cannot be seen from any of the sites available for observing stations, it may sometimes be possible to make use of captive balloons. (See paragraph 6.)

73. *Emplacement for Machine Guns.* — In the Japanese lines north of Mukden, machine guns emplacements were introduced along the parapet, their dimensions being 8 feet wide by 10 feet deep by 3 feet 6 inches high, with splinter-proof cover about 18 inches thick.

An emplacement for two machine guns is shown in figure 22. When there is time, splinter-proof cover of the type shown in figure 12 may be added. Loopholes should usually be provided, and in case they limit the sector of fire too much, provision can be made for raising the guns to fire over the crest by means of sand bags stored in the trench. It is usually best to emplace two guns together. (See paragraph 116.)


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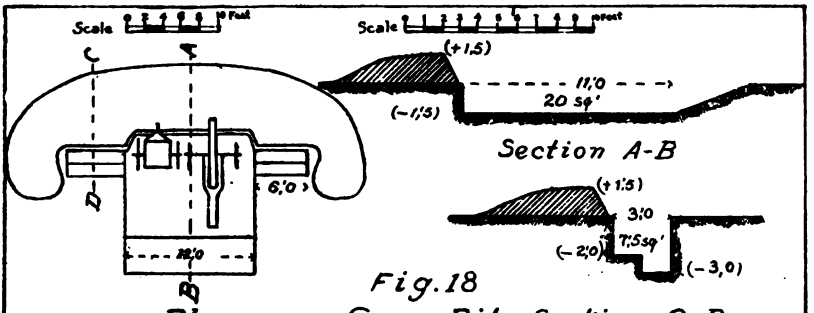


Fig. 18

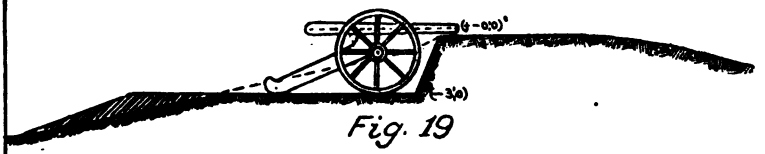


Fig. 19

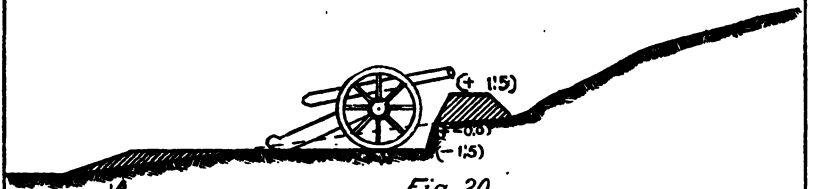


Fig. 20

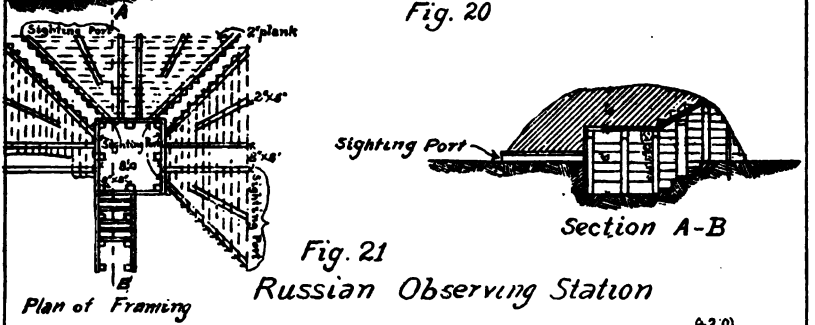


Fig. 21

Russian Observing Station

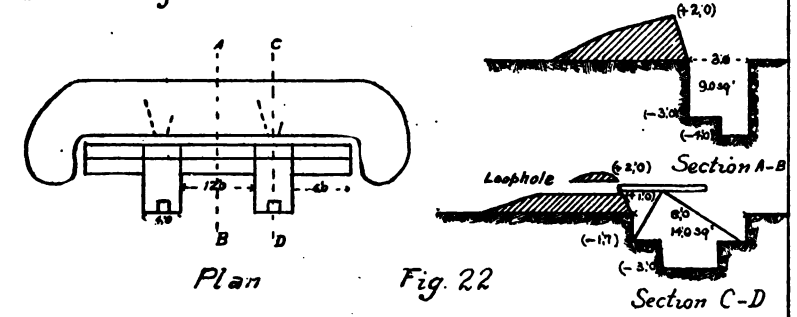


Fig. 22

Emplacement for 2 Machine Guns

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CHAPTER VI.

Auxiliary Means of Defense.

74. *Electric searchlights* will play a most useful part in defense operations of the future. Not only will they be a protection against night attacks, but also by their use, sapping or the execution of trench work by the enemy at night, at short and medium ranges, should be rendered impossible. They would be particularly useful in conjunction with light rapid-fire guns or pom-poms, or with machine guns, as with such weapons a heavy fire could be immediately developed on the object illuminated by the beam. The position of the beam in relation to the guns should be well to one side, for the best position for seeing illuminated objects is for the observer or gun-layer to have his line of sight more or less at right angles to the beam. It would be much better if the lights were not in fixed emplacements, as this would tie them to one spot; moreover, the emplacements would be conspicuous, and would be seen by day and wrecked. They should, therefore, if possible, be on traveling mountings, so as to be used from any infantry parapet or from the open. It is very difficult to hit a searchlight at night, owing to the impossibility of telling the range or observing the fire. If in addition, its position is constantly varying it would be much more difficult to hit.

75. *Interior Communications.*—The most important features of a fortress, or great defensive position, are the interior communications, and these should be the first of

the works commenced in preparing a place of defense. In laying out the communications, regard must be had to the probable tactical organization of the defending force. It is desirable to have a road or roads from the headquarters of each section to the different main supporting points in that section, also a road from the town or general headquarters—that is to say, from the main supply and ordnance depots—to each sectional headquarters. In addition to these radial roads there must be a road or railroad all around the circumference of the position in the rear of the works. It is most necessary that the communications, particularly the circumferential ones, should be screened from the enemy's view.

The movement of troops being the principal element of success, the communications, and especially those which must assure the execution of counter attacks or of offensive returns, have a prime importance. These lines of communication should be so placed as to be defiladed as far as possible, and so that they can be utilized during the whole course of the combat.

76. *Telegraphic and Telephonic Communication* should be provided between all parts of the position; that is, from the fortress headquarters to each sectional headquarters, and thence to each important work or group of works in the front line, and also to the artillery commander's posts. (See paragraphs 13 and 58.)

77. The *water supply* of a fortress is a most important matter. It is obviously necessary that the place should not be dependent for this essential requirement upon an outside source. If its supply is by means of a conduit or pipe from a distance it is extremely possible that the besiegers will find and sever it. It is most necessary, therefore, that for war times, at all events, it should

be possible to obtain a sufficient supply for the garrison and the civil population from sources within the defended area; that is to say, from wells. A considerable economy can generally be effected by restricting the use of the pure water to drinking and cooking only, and there will usually be streams or rivers whence water for washing and cleaning can be obtained. If the only supply is from a river, it will be necessary to take steps to sterilize the water by boiling or otherwise, before it is issued to the troops for drinking.

CHAPTER VII.

STRENGTH OF GARRISON.

78. The following considerations will have to be taken into account in *determining the number of men per yard* necessary for an efficient defense:

1. The enemy's strength and armament.

2. Whether the position is circular or crescent shaped, so that reinforcements from the center can be rapidly sent to any desired point. Or if it forms a long line with slightly or no refused flanks, and if so, whether means, such as railways or good, concealed roads, exist by which reinforcements may be despatched.

3. Nature of the ground and artificial improvements; that is, if good cover is obtainable, if good communications exist, if the position is hastily intrenched, or deliberately prepared for defense.

4. Character of defense; that is, whether or not an offensive return is contemplated, and length of time the defense is to be maintained.

79. When a force is *suddenly compelled to occupy a defensive position,* with opportunity to make only the most hasty form of intrenchments, no fixed or even approximate rule for determining the number of men per yard of front, is possible. The number per yard of front held at the commencement of the engagement would at times be greater than in the attack, as in the defense much greater depth of formation is necessary, and the reserve bears a larger proportion to the whole force. Thus three or four men per yard of front might be required.

80. *When from twelve to twenty-four working hours* may be available for preparing a position for defense and no offensive return is contemplated, the number of men per yard of front can be considerably reduced.

81. *For positions elaborately fortified,* having a circular form, the number of men per yard could be very small, but as such positions would only be prepared where a continued defense was required, an increase in the number of men per yard of front would be necessary to enable casualties to be replaced.

82. *In estimating the strength of garrison* necessary for a carefully prepared defensive position, the best method is to begin with the *infantry,* taking each section of the defensive area separately. The garrison of the works can be calculated with fair accuracy by measuring the actual length of the lines of infantry parapet, and allow not less than two men for each yard. Of this number about one-fourth should usually be in the supports and one-half in the section reserve. (See paragraph 13.)

83. The *strength of the artillery* may be estimated at thirty men per medium and heavy gun (three reliefs of ten) and eighteen men per light rapid-fire gun. If available, some field artillery with the section reserves will often be useful. The *engineers* should, if possible, be not less than one-twentieth of the strength of the infantry.

84. The *strength of the general reserve* would depend mainly on the facilities that are likely to be obtained for active measures. It is desirable to have it equal in strength to the total of the section garrisons; and, in any case if possible, not below half that strength. Mounted troops and field artillery would be usefully employed with this reserve if the defended area is a large one.

85. The following examples serve to show to what extent local conditions govern each particular case:

At Plevna in 1877, where all the defenses were constructed after the first Russian attack, the Turkish garrison during the investment numbered 1,875 men per mile of perimeter of defense, or about one per yard. The place was held for five months and resisted all the Russian attacks.

At San Juan, Cuba, on July 1, 1898, the Spanish force of 1,197 men held a line about one and one-half miles long, of no great natural strength, and not carefully prepared for defense, nearly all day, against the American force of 8,412 men; and inflicted a loss of 1,156 in killed and wounded.

At Nanshan Hill in the Russo-Japanese War, the Russian force of 18,000 men and 55 guns held the position for a day against the Japanese force of 42,000 men and 216 guns. The position was an ideal one for defense, being a hill 400 feet high, which rose in the midst of a peninsula only two miles wide. It had been carefully prepared for defense. The actual garrison of the hill was only one regiment. Two assaults were repulsed and the third succeeded because the Russians had not extended their lines of obstacles far enough into the sea, and did not bring up their reserves.

At Port Arthur in 1904, there were 4,755 men concentrated along the assailed front of two and one-third miles, and 7,730 men on the unassailed front of ten and two-thirds miles. The reserve of the attacked front consisted of 406 men; the reserve of the unattacked front of 496 men, and the general reserve of 510 men. Con-

sequently there were 2,038 men per mile on the attacked front, or 1.16 per yard. On the unattacked fronts there were 725 men per mile, or 0.41 per yard. (See the last part of paragraph 45.)

CHAPTER VIII.

Defense of Small Isolated Posts Occupied by Detachments.

86. The foregoing has dealt mainly with the case of a fortified position, held by at least an independent brigade, and liable to be attacked in force; a situation, in fact, which would probably be met with at points of strategical importance.

87. At *places where only a small force would be available* for the defense, certain modifications would be necessary. In such a case so extended a line could not be taken up, so it would be impossible to have the defensive line so far out as to keep the enemy beyond bombarding range of the town, and the supporting points would probably be closer together. The general principles and methods of defense would, however, be similar to those already described, subject to such modifications as the altered conditions would require.

88. The case would be different when the *position was quite a small one* to be held by a small isolated detachment, as might exist for the defense of a bridge, or a post on a line of communications, on which an attack in great force or a very prolonged siege was not anticipated. In such a case a widely extended position, made up of supporting points at intervals, would be impossible. The smallness of the defending force would necessitate its remaining more or less concentrated.

89. Instead of providing a continuous redout or fort, it would be better to construct *simple trenches or*

parapets, in such a manner as to interfere as little as possible with the natural appearance of the ground; in fact, to rely on skilful treatment of the natural features of the position selected.

90. An isolated position of this nature would have to be prepared for *all-around attack,* so some of the trenches and emplacements would be required to face to the rear, and care would have to be taken to avoid the possibility of receiving fire in reverse. Shelters for the reserves would be necesary in some central part of the position, and this should be bomb-proof if possible, and in any case well concealed. Shelters for storage of supplies, ammunition, etc., would be required, and the important question of water supply must not be overlooked.

91. The position selected for defense *would not* in such a case necessarily *contain* within itself the *object to be defended.* It would hardly ever be possible to find a position that could be defended by a small force immediately round the object, if the latter were a bridge, railway station, or place of that nature; it would usually be sufficient if the position commanded the object and the approaches at short ranges. Sometimes it might be necessary to make the defenses in the form of two positions supporting each other, and both commanding the object.

92. *If the enemy is uncivilized or unprovided with artillery* it is evidently unnecessary to employ the elaborate methods necessary against civilized enemies. Protection against rifle bullets is easily obtained, and neither concealment nor overhead cover are in such cases necessary. Blockhouses and villages or strong buildings make good defensible positions in these cases. For the methods

of preparing these see E. F. M., paragraphs 46, 61, 62 and 63.

For a fortified post in a savage country a *material obstacle* is generally essential; so if the work itself does not provide one in the form of a wall or stockade, a strong, independent one in the shape of barbed wire entanglements or abatis should be provided. A clear field of fire is, of course, imperative, and flank defense should be provided, dead angles being inadmissible. Every fort of this nature should be self-contained; that is, should contain room for storage of supplies and ammunition, and should be possessed of its own water supply.

CHAPTER IX.

FORTIFICATIONS ON THE OFFENSIVE.

93. Fortified positions will be used in the field by armies on the *offensive* as well as on the *defensive*. The fortifications erected by the *former* will generally be of a hasty and slight character, thrown up by its outposts for protection against sudden attack, and for the purpose of holding the ground then occupied, but soon to be abandoned in an advance movement.

Those used by the *latter* will often be of the character just described, if the army is advancing or retreating, but in retreat it may also make use of positions carefully selected and strongly fortified, previous to the arrival of the main body of the army.

94. *Fortifications* will also be used by both armies on the *battlefield* to enable the lines to hold the positions they may occupy at the time, and such works will be thrown up after the beginning of the engagement. The same body of troops may create two or more lines of trenches or breastworks in a single day as it advances or falls back; the works must necessarily be of slight strength at first, but if the troops remain undisturbed for a few hours the line may become strong. This method of fortification was carried to a higher degree of perfection in the Civil War of 1861 to 1865 than it ever was before or has been since; as owing to the length of that conflict, the soldiers learned to appreciate the value of the spade to an extent that no amount of peace instruction or drill can equal. The battle of the Wilderness is a good illustration of this fortification of the battlefield;

that conflict, which began by both armies assuming the aggressive, terminated by each being so strongly intrenched that the other did not consider it prudent to continue the attack.

95. In the face of an active defense, multiplying its counter attacks and offensive returns, *the attack* will have great difficulty in maintaining itself in the conquered positions where it will nearly always, immediately after the capture, be compelled to take up the defensive attitude for a certain length of time. It must therefore have recourse, like the defense, to the resources of fortification, in preparing the boundaries of woods and villages, in making the intrenchments face the other way, or in building new ones, and in doing these things as rapidly as possible.

In darkness or fog an advance may be made close up to the defensive line and a good intrenched position taken up.

96. *The location* of the fortifications of this character upon the battlefield will be determined by the position of the line. Troops in contact with the enemy can not remain stationary without cover. An advance can be made in the open, utilizing such natural cover as may exist at the locality. A withdrawal in the open is more difficult than the advance; and, with modern weapons, is more destructive, unless the attention of the enemy can be retained by other covering bodies of troops. To remain without cover in the open is annihilation. An advancing force, if it cannot push its way further, must obtain cover where it is or go back. The former will be less costly, and if the line cannot be reinforced, it will be best to get such cover as it can manage to throw up, and hold on until dark. What is called the skirmisher's

trench, or pit, can be excavated by a soldier while lying down, and will be what he will try to secure after having heaped a mound of earth or secured any other cover in front of his head in the most expeditious manner possible. (See paragraph 9 and figures 3 and 4, E. F. M.) Similarly a line that is being pushed slowly back will endeavor to intrench itself at the first opportunity, and maintain its ground.

97. Such trenches or cover are wholly *tactical;* they cannot be prepared in advance, for they depend upon the position of the troops and must conform to that condition. They must be constructed by the troops; and that one of the opposing forces, which has its officers best able to advantageously locate the trenches within the limits allowed, its men trained to realize the importance of cover and provided with means for doing the work in the shortest time, will have a great advantage over an army deficient in any one of these respects.

Such constructions will ordinarily form intrenched lines rather than fortified positions, although the latter may be developed from them.

Major Kuhn states: "In their attacks on the Russian positions, the Japanese firing lines, lines of support, and reserves frequently constructed hasty intrenchments as they advanced over the fire zone. These intrenchments were of the simplest form to give cover quickly, being thrown up with the portable intrenching tool carried by the soldiers, and giving cover lying down or kneeling. They served to cover the successive advances of the infantry line, being occupied in turn by the firing line, lines of support, and reserves, and being continually strengthened by the rearmost lines."

Major Morrison states: "Around Liaoyang hasty intrenchments were frequently used by the Japanese. Troops pushed forward against the Russian works, when checked, threw up hasty cover, sometimes kneeling or lying, but more generally merely head cover. This consisted simply in digging and throwing the dirt to the front, height and thickness depending on the circumstances of the case.

"At this place I saw cover constructed for the reserve. It consisted of parallel mounds of earth thrown up about 20 paces apart and about 3 feet high, including the trench, behind which the troops could sit. I was told it was effective cover for shrapnel. They were out of range of infantry fire.

"In the advances on the Sha River hasty intrenchments were in constant use. They presented no new features.

"One trench constructed by the Russians and captured by the Japanese was converted to their own use by the latter by digging a trench on the reverse side.

"As far as I could observe or find out by questioning, the hasty cover, either kneeling or standing, was safe cover from shrapnel while the men remained close behind it."

General Kuropatkin in his "Study of Japanese Tactics," states: "We once had an opportunity of closely watching an advance made by the Japanese against the front of the position held by the Thirty-eighth Alrofski Infantry Regiment.

"They attacked in widely extended skirmishing order. The firing line advanced at the double for a short distance, lay down, and commenced to dig. Notwithstanding our extremely heavy fire, they again doubled for-

ward, giving up their half constructed trenches, and began to dig new ones. The supports then doubled forward and occupied the first trenches and completed them. When the firing line advanced from the second line of trenches, these were occupied by the supports, and the reserves then moved up into the first line of trench. The advance continued by successive rushes in this manner."

98. *Siege Operations.*—Any field army may be called upon to attack fortified places, and such operations may include all the refinements of regular siege operations. (For the details of siege operations see paragraphs 65-118, E. F. M.)

CHAPTER X.

Calculation of Men and Time Required to Execute Defensive Works.

99. *Tasks.—The capacity of the average untrained man* for continuous digging does not much exceed 80 cubic feet for easy soil, 60 cubic feet for medium, and 40 cubic feet for hard soil. He will do three-eights of this in the first hour, five-eights in the first two hours, and the other three-eights in the other two hours. In addition to the fact that he works but a little over half as fast in the second two hours, four hours' work will leave him unfit for fighting or marching, while after two hours' work he should be able to do either. The quantity of work assigned to each relief should be that which can probably be done in two hours, and the relief is required to finish it and no more, whether it takes less or more time. For the first work, the soil is apt to be loose and the lift less, so that a slightly greater task should be given to the first relief than to the second. Assuming men at five foot intervals and neglecting fractions, the number of hour's work required to throw up a parapet is the section of the parapet in square feet divided by five for easy, four for medium, and two and one-half for hard soil.

When men and tools are plenty and it is desirable to complete the work promptly, the tasks may be made four feet long, but at night five foot intervals are necessary to prevent interference or possible injury to the men. (See E. F. M., paragraphs 37-43.)

100. *Double Gangs.*—When men are plenty, tools

are scarce, or time presses, a task may be completed in about two-thirds of the ordinary time by detailing two men at each set of tools. The two gangs change off at frequent intervals and the men work as rapidly as possible.

101. Where *traction ditchers* are available, as in many cities and towns, they may often be advantageously used to construct infantry trenches. Some forms can dig a ditch thirty inches wide and three feet deep at the rate of one yard per minute.

102. The *Fort Riley* redout (figure 205, E. F. M.) for one battalion could be constructed by its garrison in six days of ten hours. If plows and scrapers were used in addition to the men, it would require about four days. (See paragraph 42.)

103. The *Russian* redout (figure 1) for one company could be constructed by its garrison in about six hours in ordinary soil. (See paragraph 42.)

104. The *Japanese* redout (figure 2) for one battalion could be constructed by its garrison in two days of ten hours. (See paragraph 42.)

105. The profile shown in figure 3 has a trench area of cross section of 6 square feet, and applying the approximate rule in paragraph 99, could be constructed in from one to two hours. The profile shown in figure 4 with a trench area of 9 square feet would require from two to three hours. (See paragraph 45.)

106. The triangular profile shown in figure 5 with a parapet area of 22 square feet could be constructed in from two to four hours with two men per 4 feet of length. The triangular profile shown in figure 6, with a parapet area of 44 square feet, could be constructed

in from four to eight hours, and would require three men per 4 feet of length, on account of the excessive horizontal movement of earth necessary. For the additional men necessary for the construction of the revetment, see paragraph 117. With a scraper and plow 20 to 30 feet of parapet could be constructed per day of eight hours. (See paragraph 45.)

107. The Japanese profile shown in figure 7 has a trench area of 20 square feet and could be constructed in from four to eight hours. That shown in figure 8 has a trench area of 28 square feet and could be constructed in from six to eleven hours. (See paragraph 45.) In both these profiles two men per 5 feet of length could be worked and the time could be halved. For the additional men necessary for the construction of the revetment, see paragraph 117.

108. The Russian profile shown in figure 9 has a trench area of 18 square feet and could be excavated in from four to eight hours. The loopholes, loophole covers and sand-bag traverses would require about four hours additional. This trench was actually constructed in two nights. (See paragraph 45.)

109. The profile shown in figure 10 has a trench area of 16.5 square feet and could be excavated in from four to eight hours. The construction of the splinterproof would require an extra man per 5 foot task. (See paragraphs 46 and 49.)

110. The loophole cover, figure 11, could be constructed in half an hour by one man if the materials were convenient. (See paragraph 46.)

111. The earthwork of the profile shown in figure 12 could be executed in from two to three hours. The

loopholes and overhead cover would require two hours additional. (See paragraph 49.)

112. The splinter-proofs shown in figures 13 and 14 would require from one to two hours for construction with two men per 5-foot task, if the materials were at hand. (See paragraph 49.)

113. The communicating trench, figure 17, has an area of 12 square feet and could be constructed in from two to four hours. With a width of 2 feet it would have an area of 8 square feet and would require from one and one-half to three hours. (See paragraph 55.)

114. The gun pit, figure 18, has a total volume of excavation of 330 cubic feet and could be constructed by twelve men in from one to two hours. (See paragraph 67.)

115. The Russian observing station, figure 21, could be constructed by ten men in eight hours. (See paragraph 71.)

116. The emplacement for two machine guns, figure 22, has a total volume of excavation of 340 cubic feet and could be constructed by eight men in from one and one-half to four hours. (See paragraph 73.)

117. The following table gives the time required to execute different kinds of work in hours of one man:

Description of Work.	*Figure in Engineer Field Manual, Part 5*	*Work done by one man in one hour*	*Remarks.*
Cutting brushwood 6 years old		15 sq. yds.	Cutting only.
Felling trees with axe, untrained men:			
4 in. diameter		No. 30	2 men to each tree.
6 in. diameter		10	
9 in. diameter		6	
12 in. diameter		3	
18 in. diameter		2	
30 in. diameter		0.6	
Abatis, small trees close at hand, 10 yds. wide	90	0.25 yd.	
Slashing, 10 yds. wide	91	1 yd.	At edge of woods, etc.
Low wire entanglement, 10 yds. wide		1 yd.	
High wire entanglement, 10 yds. wide	101	0.3 yd.	
Military pits, 5 rows	104	0.5 yd.	
Walls, loopholes cut with chisels	109	No. 4	1 man to each.
Walls, notches at top	108	No. 20	1 man to each.
Gabions	64	No. 0.3	3 men to each.
Fascines, 18 ft.	55	No. 0.2	5 men to each.
Hurdles, 6 ft. by 2 ft. 9 in.	61	No. 0.2	3 men
Sand bag revetment	53	8.8 sq. ft.	5 men
Sod revetment	54	5 sq. ft.	
Continuous hurdle revetment		2 sq. yds	
Gabion revetment	65		Executed at same time as earthwork.
Fascine revetment	59		
Overhead cover	34	4 sq. ft.	Not including earthwork.
Siege gun emplacement	118	0.005	70 men, 10 hrs.

CHAPTER XI.

Field Problems in Fortification.

118. Field Problems in Fortification are intended to take up the details of the phase of terrain exercises, such as are given in the Military Art Department, following the issuing of the order for taking up a defensive position.

119. The course in Field Problems in Fortification for the Staff Class consisted of eight problems for which 34 half-days were employed.

In the first five problems the force involved was a detachment consisting of a regiment of infantry, a battery of field artillery and sometimes a troop or more of cavalry. The problems were varied by placing them on different kinds of terrain, by varying the time available for the preparation of the position, and by variations in the probable direction, nature, and strength of the expected attack. For problems involving a force of this size three half-days were employed.

On the first half-day a general examination of the terrain was required, with a statement of the general position to be occupied; division into sectors, and force assigned each; position and strength of the reserve; the position of the artillery, kind of fire to be employed and shelter to be constructed; disposition and use of the cavalry.

On the second half-day a more detailed examination of the terrain was required, with division of the force into first line and supports; location and design of the infantry works and garrison of each; position and shelter

for supports; communications and approaches to be constructed; obstacles; clearing of the foreground; and demolitions to be executed.

On the third half-day the problem was discussed on the ground. During the discussion the instructor read a summary of the various solutions, and required different officers to explain any unusual dispositions, inviting a free discussion of all the points involved. Details were then made to trace the various trenches and positions. The locations were discussed by the whole class, and the best location at each point decided upon. When the time permitted, the whole line was traced on the ground simultaneously, by assigning officers as commanders of the various units and requiring them to issue their orders and trace the trenches of their commands. Each officer was provided with a sharpened stake about three feet long to which was attached 25 yards of tracing tape or cord. With these stakes the actual length of the trenches to be constructed could be traced on the ground by assigning the proper number of officers at each trench. In this way the officers can get a proper idea of the amount of ground covered by the trench of any unit.

After a discussion of the problem an approved solution was issued by the department.

The sixth problem involved a force of a detached brigade consisting of three regiments of infantry, a squadron of cavalry, a battalion of field artillery, a company of engineers, a company of signal corps, and a field hospital. For this problem five half-days were employed.

On the first half-day the following requirements were solved: General position to be taken up; the division into sectors, and the force asigned each; the position and

strength of the reserve; the location of the field artillery, character of the protection to be provided, and kind of fire to be used; disposition and use of the cavalry; duties to be assigned the engineer and signal companies; location of the field hospital, ambulance and dressing stations.

On the second half-day the first sector was taken up in detail in the same manner as in the smaller problems. The third half-day was devoted to a discussion of the previous work.

On the fourth half-day the dispositions of the second sector were required; and were discussed on the fifth half-day.

The seventh problem involved the dispositions and defensive works of a division with siege artillery, which was part of a force of a corps of three divisions required to take up and hold, for about a month, a strong position covering the bridges across the Missouri at Leavenworth and Fort Leavenworth, assuming about ten days were available for the preparation of the position.

Ten half-days were allowed for the solution and discussion of this problem, which was taken up first in general and then in detail as in the sixth problem.

The eighth problem involved an attack of a brigade, with siege and field artillery, an engineer battalion, signal company and field hospital, by regular siege methods, on a part of the line prepared for defense in the seventh problem; under the assumption that the position had been invested by a force of two corps with a siege train. Four half-days were devoted to this problem.

On the first half-day were required: The location of the brigade park; the location of the siege artillery, character of the emplacements, observing stations; the

location of the field artillery, character of the protection to be provided.

On the second half-day: Location and construction of the first parallel; and the approaches to the front and rear.

On the third half-day: Location and construction of the second and third parallels and approaches; duties assigned the engineer battalion and signal company; location of field hospital, ambulance and dressing stations.

The fourth half-day was devoted to a discussion of the problem and laying out the parallels and approaches.

120. The chief value of these problems is their solution on the terrain itself, and the actual laying out of the works on the ground. The map is only used to enable the instructor to determine the dispositions of each officer and to have a record of the work done by each.

121. The following general instructions were issued the Staff Class for the course:

(1) Each officer will be equipped with a pad 5x8 inches, pencil, pocket knife, field glass, scale of yards 3 inches to 1 mile, scale of slopes, "Applied Principles of Field Fortification," and Part V, Engineer Field Manual.

(2) A map for each problem, scale 3 inches to 1 mile, will be issued.

(3) On the half-days scheduled for the discussion of problems, each officer will be issued tracing tape and stakes for locating trenches on the ground.

(4) In the field problems all decisions and locations will be made after a careful examination of the ground. The map is issued only for purposes of identification and

record, and all works will be clearly and accurately indicated on it to scale.

(5) The solution of the problem will include any necessary explanation of the notations made on the map; brief reasons for decisions made or work to be executed; drawings of profiles and sections of work not in the manuals issued; estimates of time and force required to execute each part of the work; order in which each part is to be undertaken; methods to be used; tools and material necessary; arrangement of working parties, and total time to be devoted to the preparation of the position.

122. After several problems of the same type have been worked out in detail as above described, so that the student officers understand the amount and kind of work that can be done in a given time, the class may be given a situation and required to trace the trenches, approaches, points of support, and positions of supports, reserves, artillery, etc., in the time that it would have to be done in actual service. Officers may be assigned to commands, and required to issue their orders, with and without maps of the terrain.

When the entire position has been traced upon the ground, the class should go over it and discuss the various locations.

123. The following problems selected from those given the Staff Class are given as examples of the simpler ones in the course. A solution of each problem is also given with the dispositions indicated on the map. It must be understood that these are in no sense map problems, but are solved on the actual terrain, and that they are indicated on the map only to give an idea of the dispositions made on the ground.

The maps are all of a scale of three inches to one mile, too small a scale to indicate the dispositions accurately.

124. In order to obtain the most benefit from these problems, it is recommended that the student make his own solutions on the map, before reading the solutions given. The map of Fort Leavenworth and Vicinity, scale 4 inches to 1 mile, is best suited for this purpose, and can be obtained from the Secretary of the Army Service Schools.

FIELD PROBLEM NUMBER ONE.

General Situation:

A Red battalion which was sent from Platte City, Mo., (12 miles east of the Taylor S. H.) to capture supplies collected at Lowemont, Kan., (6 miles west of the Taylor S. H.) having encountered a superior Blue force at the latter place, has retired via the Millwood road.

Special Situation—Blue:

The Blue pursuing force: 1st Infantry; Battery E, 3d Field Artillery; and Troop C, 5th Cavalry, is under command of Colonel A, who has orders to drive the Red force east of the Missouri River, and seize the Fort Leavenworth bridge.

The remainder of the Blue force (2d and 3d Infantry) which was delayed at Lowemont, cannot reach the Taylor S. H. before 3 P. M., September 23, 1908.

At 10 A. M., when Colonel A at the head of the main body arrives at Taylor S. H., he receives a captured message stating that five battalions of infantry and one battery of field artillery are on their way to reinforce the Red battalion, and expect to reach 986 at noon.

The cavalry reports that the Red battalion has deployed on the edge of the woods near Kern, leaving a small force near 854.

Colonel A decides to take up a position and to prepare it for defense, in order to hold back the enemy until the arrival of the remainder of the Blue force.

The Leavenworth bridge has been destroyed.

Required:

First Part.

1. The general position to be taken up.
2. Division into sectors, and force assigned each.
3. The position and strength of the reserve.
4. The position of the artillery, kind of fire to be employed and shelter to be constructed.
5. The disposition and use of the cavalry.

Second Part.

6. For each sector:

(a) The division into first line and supports.

(b) Location and design of infantry works and garrison of each.

(c) Position and shelter for supports.

(d) Communications and approaches to be constructed.

(e) Obstacles to be constructed.

(f) Clearing of the foreground.

(g) Demolitions to be executed.

Third Part.

Discussion of the problem on the ground.

SOLUTION—FIELD PROBLEM NO. 1.

First Part.

1. Hill 883—hill 875—hill 862, overlooking Salt Creek. This position has a clear field of from 400 to 600 yards west of Salt Creek, a strong obstacle in its front, and its flanks are well protected. Salt Creek is about fifty feet wide, with two to four feet of water, a very soft bottom, and vertical banks ten to fifteen feet high.

The extreme front is 1,500 yards, but the main position, excluding hill 862 and the positions of the supports, is 900 yards long. The working parties will be under long range infantry fire (1,600 yards) of the enemy at the edge of the woods east of Kern, but can be protected by a force thrown out to the front near Sharp.

An alternative position is that along the ridge 932—886, which has the advantage of being out of range of the enemy, but would give up the obstacle of Salt Creek and the ground to the west, and would make a later advance all the more difficult. It has practically no better field of fire and has no strong positions for the flanks; see pars. 7-18 and 78-85.

2. Right sector: Kickapoo—Leavenworth road inclusive to Millwood road exclusive. Left sector: Millwood road to hill 862, both inclusive. One battalion is assigned to each sector; the machine gun platoon to the left sector; see pars. 22, 23 and 38.

3. At 865, one battalion. This is a central location, well covered by the road cut, and is near the more exposed right flank; see pars. 26 and 84.

4. At hill 886. Indirect fire will be used at first; if necessary, direct fire will be used to reach the attacking infantry. No artificial cover will be constructed. This position is well protected from the hostile artillery which would probably be posted on Hancock Hill. It covers the edge of the woods east of Kern at a range of 3,200 yards, enfilades the ravines on each flank of the main infantry line and is well separated from the infantry positions; see pars. 15, 30-34, 65, 67 and 68.

5. The cavalry will be ordered to keep touch with the enemy; and when driven in, cover the right flank, sending a squad to the left.

Second Part.

6. (a) For each sector: Three companies in the first line; no local supports; sector support, one company. Local or company supports will not be employed, as the reverse slopes are too gentle to afford cover from artillery fire; the firing trenches will probably not be subjected to much artillery fire; there are no good covered approaches to the firing line, and the enemy's attack is likely to develop suddenly from Salt Creek; see pars. 23, 78, 79 and 82.

(b) See map. Trenches are constructed for eight companies, 120 yards per company; total length, 960 yards. With tasks of five feet per man, this will require $3/5 \times 960 = 576$ men.

Profile: Standing trench, see figure 3. This has an area of cross section of 6 square feet. The soil is clay and may be classed as medium. $6 \div 4 = 1\frac{1}{2}$ hours required to complete the trench; see pars. 99 and 105. No concealment, loopholes, nor dummy trenches, as work will have to be done in view of the enemy, and the time is limited. Trench for H company will be concealed by the standing corn. The profile adopted with its low and flat parapet is very inconspicuous; see pars. 45 and 63.

Machine gun emplacement constructed by platoon in two hours, with sand bag loopholes, covering the Millwood road; see pars. 73 and 116, and figure 22. Sand bags will be stored in trench so that the guns may be raised to fire over crest of parapet, if wider field of fire becomes necessary.

Tools required: Those carried by the men and in the wagons, including those of the reserve. See appen-

dix. Practically no tools can be obtained from the neighboring farms. Work will be done in one relief, seventy-two men in each company with shovels, twenty with picks.

(c) See map. G Company will scarp the reverse slope and throw the earth to the front so as to give cover for men sitting, for a length of fifty yards. This requires $3/5 \times 50 = 30$ men, $\frac{1}{2}$ hour, and will be done when the company completes its firing trench. A company is protected by a retired firing trench as shown on map; see par. 56.

(d) None, on account of lack of time, men, and tools; see pars. 55 and 75.

(e) None except those involved in f; see par. 59.

(f) Standing corn in front of E and H Companies broken down parallel to the front by dragging a log over it with a team. Trees and brush along the west side of Salt Creek slashed; see par. 60. For this work there are detailed $105-92=13$ men from each of the eight companies, for $1\frac{1}{2}$ hours, with the axes and hatchets carried by the companies; see appendix.

(g) The Daniels houses in front of E and G Companies will be burned. The bridge at 789 should not be destroyed, as it would be needed for a future advance of the detachment; see par. 61.

The work to be carried on simultaneously except the support position for G Company. The men will be worked $1\frac{1}{2}$ hours in one relief. Total time to complete the preparation of the position, two hours.

The 3d Battalion detailed for the reserve is assumed

to have been in the advance guard. It will keep down the fire of the enemy while the trenches are being constructed, by crossing Salt Creek and occupying the hill west of 854. When the work is completed it will fall back to its position at 865.

FIELD PROBLEM NUMBER TWO.

General Situation:

A Blue division is retreating through Leavenworth towards Atchison (18 miles northwest) pursued by a Red division.

Special Situation—Blue:

The Blue rear guard consisting of: 2d Infantry; Battery B, 3d Field Artillery; Troops C and D, 7th Cavalry, has, on September 14th halted for the night near the Taylor house on the Leavenworth-Kickapoo road. At 6 P. M. the rear guard commander receives orders to hold the ground south of Plum Creek until noon September 15th. Information is received that the immediate pursuing force of the enemy consists of about 4,000 men of all arms, and is camped in Leavenworth, with outposts on the ridge west of town.

The rear guard commander decides to take up a defensive position and to fortify it as strongly as the time permits.

Required:

First Part.

1. The general position to be taken up.
2. Division into sectors, and force assigned each.
3. The position and strength of the reserve.
4. The position of the artillery, kind of fire to be employed, and shelter to be constructed.
5. The disposition and use of the cavalry.

Second Part.

6. For each sector:

(a) The division into first line and supports.

(b) Location and design of infantry works and garrison of each.

(c) Position and shelter of supports.

(d) Communications and approaches to be constructed.

(e) Obstacles to be constructed.

(f) Clearing of the foreground.

(g) Demolitions to be executed.

Third Part.

Discussion of the problem on the ground.

SOLUTION—FIELD PROBLEM NO. 2.

First Part.

1. The main line of defense: Along the J. Aaron ridge from road 874—812 to include hill 862. An advanced line from the Sprong house—hill 883—hill 875 will also be held. The main line has a length of 1,800 yards; it has a good field of fire of about 800 yards; its left flank is strong, the right is rather weak, but can be covered by the artillery and cavalry; the reverse slope is steep and offers good cover for the reserve; the hedges and barbed wire fences in front afford good obstacles. In order to give more depth to the position and delay the enemy, the advanced line is occupied by part of the force; see par. 8. This position has a front of about 1,700 yards and a good field of fire of about 500 yards; its

flanks are weak, and the reverse slopes are too gentle to afford cover for supports and reserves from artillery fire; it is therefore not suitable for the main position. In this problem the ground south of Plum Creek has to be held for five or six hours, and this can best be done by causing the enemy to deploy before the advanced position, the defenders of which can retire by the ravines in rear without masking the fire from the main line; see pars. 7-18 and 78-85.

2. Right sector: from the road 874—812 to the Leavenworth-Kickapoo road inclusive. Left sector: from the Leavenworth-Kickapoo road exclusive to hill 862 inclusive. One battalion is assigned to each sector, the machine gun platoon to the left; see pars. 22, 23 and 38.

3. At 803, one battalion. This is a central position well covered by the steep slope; see pars. 26 and 84.

4. At hill 849. Indirect fire will be used. No artificial cover will be constructed. This position covers the exposed right flank of each line and enfllades the ravines and railroad along which the main attack of the enemy is likely to be made. It is well separated from the infantry positions, especially the position of the reserve. It would be very difficult for the enemy's artillery, which is probably superior, to find this position; and it is about 4,000 yards from Sentinel Hill and Bell Point near which the enemy's artillery would probably be located; see pars. 15, 30-34, 65, 67 and 68. Crook Point affords a good observing station.

5. To reconnoiter to the front at daylight on September 15th, gain contact with the enemy, delay his

advance, and cover the right flank, sending a platoon to the left. To execute the demolitions given in 6 g.

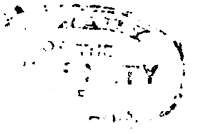
Second Part.

6. (a) For each sector: Two companies in trenches in the main line, and two in the advanced line; see pars. 23, 78, 79 and 82.

(b) See map. Trenches for 12 companies, 120 yards per company, total length, 1,440 yards. This requires $3/5 \times 1440 = 864$ men, or 72 men per company. Profile, standing trench, see figure 3. Area of cross section 6 square feet; $6 \div 4 = 1\frac{1}{2}$ hours, add $\frac{1}{2}$ hour for night work; gives total time 2 hours. Trenches will be concealed with grass in places where it is growing, by corn in the corn fields, and by top soil in plowed ground. No loopholes will be constructed on account of lack of time and materials. Dummy parapets shown on the map will be constructed by plowing two or more furrows; see pars. 45, 63 and 64.

Machine gun emplacement constructed by platoon in two hours with sand bag loopholes; see pars. 73 and 116, and figure 22. A wide field of fire will probable be necessary; this can be secured as explained in Problem No. 1.

Tools required: Those carried by the men and in the wagons (see appendix); as there are not sufficient for all the men working at once, the work will be done in two 2-hour reliefs, 492 men in each, including the work under d. Six teams and plows will be requisitioned from the neighboring farms to assist in the construction of the trenches, and to make the dummy parapets. The reserve will assist in the construction of the trenches in the main line.



(c) No supports proper will be used; the four companies in the main line will act as such for the four companies in the advanced line; see par. 56.

(d) See map. For profile see pars. 55 and 113 and figure 17, 2 feet wide. Total length, 200 yards. Requires $3/5 \times 200 = 120$ men, 2 hours, or 30 men from each of the four companies on the advanced line. These approaches will enable the defenders of the advanced line to retire gradually under cover when the enemy's attack has sufficiently developed.

(e) None except those involved in f; see par. 59.

(f) Standing corn in front of trenches broken down parallel to the front by dragging logs over it with teams; see par. 60.

(g) The steel bridges over Salt Creek at Frenchman's, at 789 on the Millwood road, and the railroad bridge at the mouth of Salt Creek will be disabled by explosives by the cavalry. Requires five pounds of dynamite per bridge, placed at the panel point of each truss, resting on the abutment; see par. 128, E. F. M. The railroad trestle at Miocene will be burned. Work will be done by patrols, four men to each bridge, after the cavalry has been forced behind Salt Creek. For tools and explosives carried by the cavalry, see appendix.

Total time to prepare position, four hours. No man will work more than two hours. The work should be commenced by 7 P. M. and finished by 11 P. M. by moonlight.

All work except that in 6 g carried on simultaneously.

FIELD PROBLEM NUMBER THREE.

General Situation:

A Blue army based on Kansas City is operating along the Misouri Pacific R. R. against a Red army, based on Omaha. In order to protect its line of communications against cavalry raids of the enemy, the Blue army has fortified various points along the railroad in its rear.

Special Situation—Blue:

Colonel A, with the 6th Infantry and Battery C, 3d Field Artillery, has been ordered to fortify Kickapoo, where there is a round-house, repair shops and materials for the repair of the railroad. It is not believed that an attack by more than a cavalry brigade with artillery is to be feared. No forces of the enemy are reported within sixty miles of Kickapoo.

Required:

First Part.

1. The general position to be fortified.
2. Division into sectors and force assigned each.
3. The position and strength of the reserve.
4. The position of the artillery, kind of fire to be employed and character of protection to be constructed.
5. Interior lines of defense.

Second Part.

6. For each sector:

(a) Division into first line and supports.

(b) Location and design of infantry works in the first and interior lines.

(c) Position and shelter for supports.

(d) Communications and approaches to be constructed.

(e) Obstacles to be constructed.

(f) Clearing of the foreground.

(g) Demolitions to be executed.

Third Part.

Discussion of the problem on the ground.

SOLUTION—FIELD PROBLEM NO. 3.

First Part.

1. Hill 1,000—873—B. Meyers—hill 903. This line is 3,000 yards long—too long for the garrison of the town; see pars. 78-85; but it is necessary to hold it, as the field of fire on the left would be too restricted if the line was drawn in to the line 865—hill 923. The field of fire on the right is good for 400-500 yards; on the left for 900-1,000 yards. Section Lane and Plum Creek form good obstacles on the left. The low ground along the Missouri River is intersected by numerous sloughs and is too marshy and wooded for an attack from the east; see pars. 87-90.

2. Right sector: North and west of the line 842—865—38. Left sector: South and east of the same line. One battalion is assigned to each; see pars. 22 and 23.

3. At 38; one battalion and machine gun platoon; see pars. 26 and 38.

4. In the ravine northwest of hill 923. Indirect fire will be employed with cover of the type shown in figure 20. Other positions will be selected for indirect fire so

that all the slopes in front of the position may be swept by fire. Observing stations will be located on hills 1000, 903 and 923. The probable positions of the enemy's artillery are Crook Point and hill 1042; see pars.15, 27, 32, 35, 65, 67, and 68.

5. No interior line for right sector; for left, line 865—hill 923. The front line is so long that it may be necessary, if an energetic attack is made, to draw in the left, giving a line about 1,500 yards long; see pars. 8, 9, and 19.

Second Part.

6. (a) For each sector Three companies in the first line, each with one section in firing trenches and three in local support; sector support, one company; see pars. 23, 78, 79 and 82.

(b) Location shown on map. Trenches for ten companies in the first line (9 company trenches and two platoon trenches); and for four companies in the second; 120 yards per company; total length 1,680 yards. Profile: Figure 4, see pars. 45 and 105. The soil is clay and may be classed as medium. To construct trenches will require $3/5 \times 1{,}680 = 1{,}008$ men, $2\frac{1}{2}$ hours. Loopholes will be constructed of sod, sand bags, or stove pipe, materials to be obtained in vicinity. Trenches will be carefully concealed with sod, top soil or brush; see pars. 46 and 63.

Splinter-proof cover will be provided for one section in each company trench, of type shown in figure 14. This will require $\frac{1}{4} \times 1{,}680 = 420$ men, 2 hours; see pars. 49 and 112.

Machine gun emplacements of type shown in figure

22, with the addition of splinter-proof cover constructed by platoon in four days at hill 1,000, hill 923, hill 903, and covering the road and railroad east of hill 1,000; see map. Splinter-proof cover of type shown in figure 12.

(c) Company supports shown on map at S. The sector supports at C and G. Protected by scarping reverse slope, ½ yard per man. This will require 200 men four hours to construct. Similar shelter will be constructed for the reserve by 100 men in four hours; see par. 56.

(d) Approaches shown on map, leading to the more advanced trenches, where no natural covered approaches exist. Total length, 800 yards; profile, figure 17. These will require 480 men three hours to construct. The existing lateral communications are sufficient; see pars. 55, 75 and 113.

(e) Slashing in the wooded ravines leading to the position, along the river road, and where orchards and woods are cleared. Section Lane hedges prepared as an obstacle by clearing out to improve the field of fire and filling the road cuts with the debris. See f for estimate of time.

High wire entanglements, five yards wide, constructed in front of trenches where no hedges or slashings have been prepared. Total length, 2,000 yards; this will require 600 men four hours to construct, material taken from barbed wire fences;see pars. 59 and 117.

(f) Woods and orchards slashed in front of trenches to at least 600 yards. The houses that interfere with the field of fire will be torn down and the material used for splinter-proofs, etc. This will require the labor of 400 men four hours; see pars. 60 and 117.

(g) None.

The tools carried by the men and in the wagons are sufficient, with a few that can be obtained in the town and neighboring farms, including teams and plows. Men will be worked four hours per day.

The work should be undertaken in the following order: First line trenches, clearing, approaches, shelter for supports and reserve, second line trenches, obstacles, splinter-proofs.

Total time required to execute the work outlined above, three days of four hours. When this work has been completed, small working parties will be employed each day to extend the clearing of the foreground, improve the concealment of the trenches, strengthen the obstacles, and increase the protection for the supports and reserve.



APPENDIX.

The following extracts from General Orders of the War Department give the tools carried by the different arms, which could be used for intrenching:

Intrenching tools carried by a company of infantry, G. O. No. 23, 1906:

½ ft. folding rule
15 pick mattocks
45 intrenching shovels
4 hand axes
3 wire cutters

The following engineer equipment is furnished each company of infantry to be carried in the extra regimental wagon, G. O. No 221, 1907:

Augur, 1-inch	1	Nails, assorted, pounds	10
Axes	6	Pliers, wire cutting	7
Crowbar, 12 pounds	1	Rule, 2-foot	1
Hatchets	6	Saw, hand, crosscut, with sheath	1
Matchetes with sheaths	20	Rope, 2½-inch, feet	250

The following engineer equipment is furnished the cavalry, to be carried on pack animals, G. O. No. 221, 1907:

To each troop:

Augur, 1-inch	1	Pick mattocks, large	5
Axes, 6-pound	4	Pliers, wire cutting	6
Crowbar	1	Rules, 2-foot	2
Hatchets	4	Saw, crosscut with sheath	1
Nails, assorted, pounds	5	Shovels, large	15

PACK DEMOLITION OUTFIT.

To each squadron:

Box, match, tin	1	Fuse, instantaneous, feet	200
Caps, detonating	100	Hammers, drilling, 7 pound	2
Chisels, cold, 1½-pound	1	Hammer, engineer's, 3-pound	1
Crowbars	2	Pliers, nose cutting	1
Drills, double bitted	2	Shoes, mule, sets	1
Explosive, pounds	50	Spoon, drilling	1
Fuse, Bickford, feet	200	Wrench, monkey	1

Allowance of tools for field service, G. O. No. 95, 1908:

Regimental Headquarters.	*Battalion Hdqrs.*	*Band.*	*M. G. P.*	*Company.*	*Total in Regiment.*
Infantry					
Axes..... 10	2	4	4	6	96
Hatchets..... 10	2	4	4	6	96
Pickaxes..... 3	1	2	2	4	58
Spades..... 3	1	2	2	4	58
Artillery				Battery	
Axes..... 6	2	4		3	32
Hatchets..... 6	2	4		3	22
Pickaxes..... 1	1	2		7	48
Spades..... 1	1	2		7	48
Cavalry	Sq. Hdqrs.			Troop	
Axes..... 6	2	4	4	6	92
Hatchets..... 6	2	4	4	6	92
Pickaxes..... 1	1	2	2	4	56
Spades..... 1	1	2	2	4	56

In addition to the above, each escort wagon carries one axe, one pickaxe, and one spade. The allowance of escort wagons, as follows:

	Regiment	Battalion	Company
Infantry.....	23	6	1
			Battery
Artilllery.....	23	10	3
		Squadron	Troop
Cavalry.....	34	10	2

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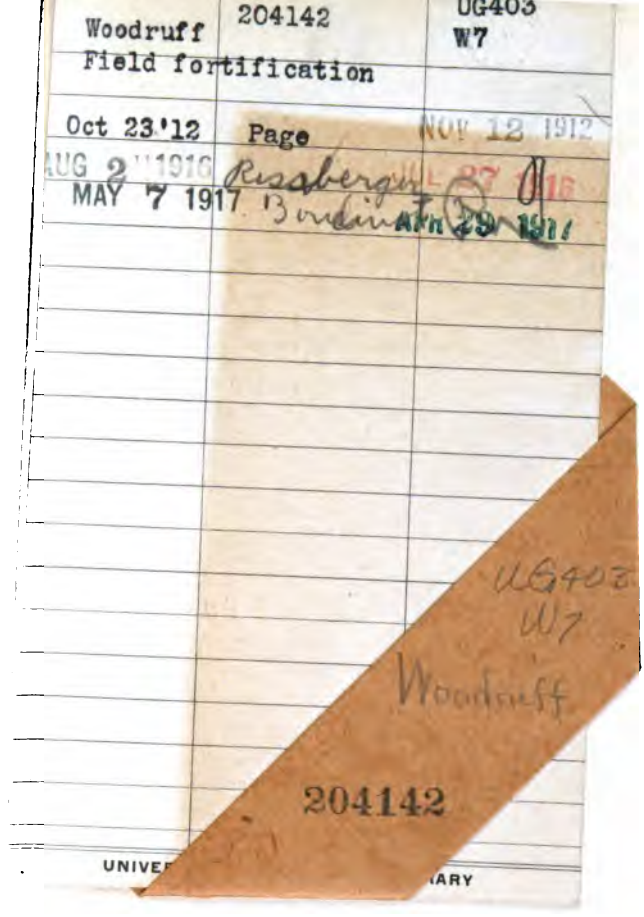
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